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CODE OF PRACTICE FOR TRAINING AND TESTING OF OXY-ACETYLENE WELDERS

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 13

November 1962

Indian Standard

CODE OF PRACTICE FOR TRAINING AND TESTING OF OXY-ACETYLENE WELDERS

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Indian Standard

CODE OF PRACTICE FOR TRAINING AND TESTING OF OXY-ACETYLENE WELDERS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 14 August 1961, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 The Planning Commission of India, while investigating the problems of shortage of steel in India, concluded that greater development in the use of welded construction would contribute appreciably to the economic and efficient use of steel. The use of welding in India has lagged far behind the use of this method of fabrication in other countries. On the recommendations of the Planning Commission, the Indian Standards Institution launched a Steel Economy Project to promote efficiency and economy in the use of steel for fabrication purposes and to introduce measures to encourage the more rapid development of the welding industry in India.

0.3 Oxy-acetylene welding is used on the whole range of commercial ferrous and non-ferrous metals and alloys. Materials, such as high-carbon and alloy steels, can be welded by oxy-acetylene welding provided the joints if required, can be properly heat treated before and after welding. Cast iron machinery frames 30 cm or more thick at the fracture point have been repaired by either fusion or braze welding (non-fusion welding). Sound welds are produced in other materials by appropriate variations in technique, heat treating, pre-heating, etc. Generally speaking, oxy-acetylene welding is no longer used in structural work in mild steel, if arc welding plant is available, except in the case of relatively thin-gauge material.

0.4 Progress in the use and acceptance of welding as a fabricating medium depends greatly upon the quality of the welding being done in the country. The value and utility of welding are judged mainly on the competency and knowledge displayed by the welder. The need for men, more skilled in the art of welding, has led to the establishment of these recommendations for the training and testing of welders.

0.5 With the increasing acceptance of welded fabrication for major structures, the uniform maintenance of a high degree of proficiency in welding is essential for the adequate protection of the public as well as the sound development of the welding industry. In addition to the initial qualification tests for judging the ability of the trainee, periodic re-tests and special trade qualification tests are essential in maintaining high standards of proficiency. Although there is a general agreement on the properties to be determined and test procedures to be used in judging the qualifications of a welder, there is a certain divergence in the details of the test procedures and number of tests required. The exercises and qualifying tests recommended in this code are considered minimum for assuring proper qualifications for normal welding in thin gauge mild steel, sheets and tubes, aluminium, brass, and cast iron, and will produce a welder with a degree of skill and knowledge that will be of immediate value to his employer and he, by gaining experience on simple work, will be able to progress rapidly to work of greater difficulty. The exercises and qualifying tests recommended are not intended to train welders for special types of welding, such as welding of boilers, industrial pipelines, etc. More stringent requirements may be necessary for qualifying welders for a special type of work if there is a definite code, specification or procedure control for that type of work or the materials to be used.

0.6 Adequate training facilities and safe and convenient working conditions are essential adjuncts to the proper instruction of a trainee. This code includes recommendations on the type of equipment essential for proper instruction in welding. Basic rules for safety in the handling and care of equipment are also included. The welder shall be made conscious of economy in the use of materials and shall be capable and cognizant of the need to make the fullest use of all filler rods and other materials he is working with.

0.7 Drawing upon the experience of established training institutions in India and abroad, this code has been formulated with a view to serving as a guide in organizing and planning the work of the trainee's undertaking a course of study in welding technique and theory. Furthermore, due weightage has been given to the need for international co-ordination among standards and test procedures prevailing in different countries of the world. These considerations led the Sectional Committee to derive assistance from the following documents:

B.S. 1295:1946 TESTS FOR USE IN THE TRAINING OF WELDERS. British Standards Institution.

AWS B 2.1-1945 CODE OF MINIMUM REQUIREMENTS FOR INSTRUCTION OF WELDING OPERATORS. American Welding Society.

0.8 Wherever a reference to any Indian Standard appears in this code, it shall be taken as a reference to the latest version of the standard.

0.9 All quantities and dimensions appearing in this standard have been given in metric system. Corresponding fps values to which the industry has been accustomed are given in Appendix J for information.

1. SCOPE

1.1 This code recommends minimum requirements for a course of instruction in manual oxy-acetylene welding and cutting — as applicable to light engineering industry (Section I) and to general engineering industry (Sections I and II) and prescribes certain standard tests comprising the initial qualification tests at the training establishment and subsequent annual and periodic tests for practising welders.

NOTE — Training for welding in overhead position has been omitted from the scope of this Code in view of its very limited application in light and general engineering industry.

1.2 The principal objectives of the course of instruction covered by the code are:

a) to coach the trainee in the fundamental techniques and safe practices of oxy-acetylene welding and cutting,
b) to give the trainee a good understanding of the proper methods of oxy-acetylene welding and cutting,
c) to enable the trainee to acquire enough skill in oxy-acetylene welding and cutting to pass the qualification tests prescribed in this code, and
d) to provide the trainee with a basic knowledge of the theory of oxy-acetylene welding and cutting.

1.2.1 The course of instruction is not expected to produce an experienced welder, but rather a welder with enough skill and knowledge so that he will be of immediate value to industry as a welder on less difficult work and will be able, by gaining experience in industry, to progress rapidly to work of greater difficulty and responsibility.

1.3 The standard tests prescribed in this code comprise the following:

a) *Initial Qualification Test* — The test which the trainee shall be required to pass before completing his course of training. The passing of this test indicates that the welder has enough basic skill and knowledge to be of value to industry as a welder; and
b) *Annual and Periodic Tests* — The check tests designed to be applied at regular intervals for ensuring that a welder actually engaged on work has continued to maintain a standard of proficiency as required by the initial qualification test.

PART I GENERAL

2. TERMINOLOGY

2.1 For the purpose of this code, all terms relating to oxy-acetylene welding and cutting, unless otherwise defined in this code, shall have the meaning assigned to them in IS: 812-1957 Glossary of Terms Relating to Welding and Cutting of Metals.

3. SYMBOLS

3.1 For the purpose of this code, the symbols used, unless otherwise defined in this code, shall have the meaning assigned to them in IS: 813-1956 Scheme of Symbols for Welding.

4. MATERIAL

4.1 Steel — Steel used as parent metal for training and testing, according to the provisions of this code, shall be of general weldable quality specified in *IS: 226-1958 Specification for Structural Steel. In the case of mild steel tubes, only those tubes having wall thicknesses up to 1·60 mm shall be used.

4.2 Cast Iron — Cast iron plates used as parent metal for training and testing, according to the provisions of this code, shall conform to *IS: 210-1950 Specification for Grey Iron Castings (machinable quality).

4.3 Aluminium — Aluminium used as parent metal for training and testing, according to the provisions of this code, shall be of quality designated S1A or S1B or S1C as specified in *IS : 737-1955 Specification for Wrought Aluminium and Aluminium Alloys, Sheet and Strip (For General Engineering Purposes).

4.4 Brass — Brass used as parent metal for training and testing, according to the provisions of this code, shall be of quality as specified in IS: 410-1959 Specification for Rolled Brass Plate, Sheet, Strip and Foil (*Revised*).

4.5 Filler Rods — Filler rods used for training and all tests according to the provisions of this code, shall conform to the requirements of **9.1** or **9.2** for welding of steel, **10.1** for fusion welding of cast iron, **11.2** for welding of brass, **11.3** for bronze or braze welding (non-fusion welding) of cast iron and **13.3** for welding of aluminium of IS: 1278-1958 Specification for Filler Rods and Wires for Gas Welding.

4.6 Fluxes — Suitable fluxes, where required, shall be used.

5. SELECTION OF TRAINEES

5.1 Trainees selected to receive the instruction recommended in this code shall have the following qualifications:

a) Ability to understand the language of instruction;

b) No physical or mental disability that precludes safe operation of welding equipment or interferes with full performance of duties in industry; and

c) The minimum age requirements prescribed in the State and Central labour laws applicable in the State in which the instruction is conducted.

---

*Under revision.

6. LENGTH OF COURSE, HOURS OF INSTRUCTION AND TRIAL PERIOD OF INSTRUCTION

6.1 Length of Instruction in Welding Practice — The instruction shall be so organized that each trainee shall be required to devote a minimum of 200 hours for both sections of the course (*see* **14** and **15**), that is 100 hours for each section, to actual welding, exclusive of time spent in witnessing demonstrations by the instructor, preparing plates for welding, testing specimens and receiving instructions in welding theory.

6.2 Length of Instruction in Welding Theory — Not less than 50 hours (25 hours for each section) shall be devoted to instruction in welding theory prescribed in Part III (*see* **17**).

6.3 Length of Welding Practice in Any One Day — The length of time spent by the trainee in actual welding practice in any one day shall not exceed seven hours with a break of at least half an hour after the first four hours.

6.4 Trial Period of Instruction — In the beginning of the course, there shall be a trial or probationary period of a week but not exceeding 40 hours, the period to be determined by the training establishment, during which the instructor shall observe the aptitude and interest of the trainee and determine whether in the interest of all concerned the trainee should continue the course.

7. RECORD BOOK

7.1 Upon completion of the course and fulfilment of the requirements prescribed in this code, the trainee shall be granted a record book indicating that the trainee has passed the tests prescribed in Part IV. Further these tests together with the results of the said tests shall be listed on the record book. If the trainee has passed some but not all the initial qualification tests prescribed, the tests which the trainee has not taken or has failed to pass shall be permanently indicated in the book.

7.2 The record book shall have additional pages for recording the results of annual tests taken by the welder. Additional pages may also be provided for recording any periodic and special tests, for example, welding in special steels, pipe welding, etc, which the welder may take. A recommended form for this book is given in Appendix A.

PART II EQUIPMENT AND TESTING FACILITIES AT THE TRAINING ESTABLISHMENT

8. APPARATUS

8.1 Welding Table — Each trainee shall be provided with a welding table preferably topped with firebrick (suggested type of table is shown in Fig. 1). The welding school shall have an area with sufficient clear floor space to allow adequate freedom of movement for the trainees and the instructors and placing of oxygen and acetylene cylinders (if supplies from cylinders are used).

8.2 Positioning Jig — Suitable positioning jigs shall be provided to facilitate the execution of the welding tests prescribed in Part IV. Suggested designs of such equipment are given in Appendix B.

8.3 Equipment for Oxy-Acetylene Welding and Cutting and Other Accessories — The training establishment shall provide all apparatus and equipment necessary for the safe and proper execution of the welding course prescribed herein. A list of accessories and equipment recommended for a training establishment is given in Appendix C.

8.4 Filler Rods and Wires — There shall be an adequate supply of filler rods and wires of the types and sizes required for the exercises prescribed in Part III.

8.5 Material for Welding — An adequate supply of mild steel, cast iron, aluminium and brass plates of the required quality shall be provided for the exercises prescribed in Part III.

8.6 Testing Apparatus — The training establishment shall possess apparatus suitable for preparing and testing the test specimens as prescribed in Parts III and IV or shall arrange for preparation and testing of test specimens elsewhere.

9. SUPERVISION

9.1 Number of Trainees per Instructor — Each shop class shall be restricted to not more than 12 trainees in attendance per instructor.

9.2 Record of Trainees' Progress — A record shall be kept of each trainee's progress, showing the number of hours of individual practice and the results of all tests prescribed in Parts III and IV. A recommended form of trainee's progress chart is given in Appendix D.

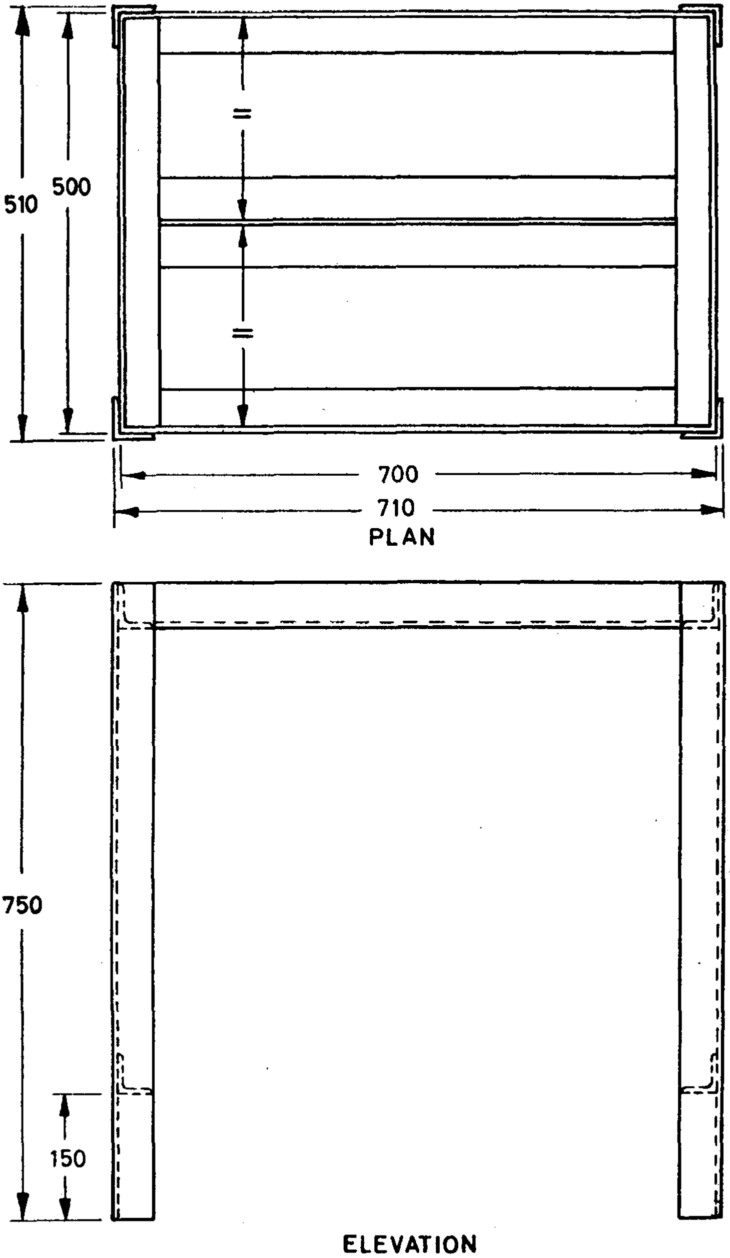
10. REFERENCE MATERIALS

10.1 Outline of Course — At the start of the course, a prepared outline indicating the syllabus of the course, the tests required, and the subjects to be covered in the related instruction shall be made available to the trainees. A specimen syllabus for the course is given in Appendix E.

10.2 Welding Publications — The training establishment shall have available for trainees' use suitable reference material on welding comprising books, manuals, periodicals, codes, standards, etc.

11. QUALIFICATIONS AND DUTIES OF INSTRUCTOR

11.1 General—The instructions prescribed in this code may be given by one or more instructors, provided each instructor in welding practice possesses



NOTE 1 — Mild steel angle 50 × 50 × 5 mm. NOTE 2 — Mild steel tee 50 × 50 × 5 mm.
All dimensions in millimetres.

FIG. 1 FIREBRICK TOPPED TABLE (FIREBRICKS NOT SHOWN)

the qualifications prescribed under **11.2.1** and each instructor in welding theory possesses the qualifications prescribed under **11.2.2.** In addition, each instructor shall have the ability to present effective demonstrations and explanations of those portions of the course which he is to teach.

11.2 Qualifications of Instructor

11.2.1 Each instructor giving any portion of the instruction in welding practice shall possess the following qualifications:

a) A minimum of three years' experience as a welder or welding supervisor, of which at least two years shall have been spent as manual oxy-acetylene welder;

b) Proven ability to pass all the tests prescribed for trainees in Part IV of this code;

c) A practical knowledge of the physical properties of the metals and the welding processes;

d) Familiarity with the topics in welding theory covered in Part III; and

e) Familiarity with the codes and specifications used in welding and capability to read simple engineering drawings relating to welding.

11.2.2 Each instructor giving any portion of the instruction in welding theory (*see* **17**) shall have a thorough knowledge of the subjects in which he gives instructions.

11.3 Duties of Instructor — The instructional staff shall be charged with the responsibility of giving instructions in welding practice and welding theory, as prescribed in Part III. The duties shall include:

a) Planning instruction in accordance with the course outlined in this code keeping in view the following four basic steps of instruction:

    1) Preparing the trainee for new instruction;

    2) Using appropriate methods for presenting the new instruction (demonstration, illustration, explanation, discussion, etc);

    3) Providing proper supervision and guidance to the trainee in applying his new knowledge and skill; and

    4) Supervising and checking tests assigned to trainees.

b) Instructing the trainee to work safely, emphasizing the training establishment's safety regulations.

c) Observing acceptable shop management practices, such as:

    1) care, control and conservation of materials and equipment; and

    2) shop cleanliness and orderliness.

d) Keeping attendance records and recording trainees' progress.

PART III COURSE OF INSTRUCTION

12. GENERAL

12.1 The instruction shall consist of welding practice and lectures in welding theory. The practical and theoretical training should be suitably interspersed and related one to the other. The training shall start with instruction in safety precautions, protection of person and protection and care of equipment.

13. INSTRUCTION IN WELDING PRACTICE

13.1 Instruction in welding practice shall be given by means of a series of exercises which shall conform to the requirements prescribed in this Part. The course of instruction has been divided into two sections as follows:

Section I — Covering welding of light gauge mild steel sheets up to 3·15 mm thick and tubes up to 60 mm diameter and wall thickness 1·60 mm (which find considerable use in light engineering industry); and

Section II — Covering welding of cast iron, aluminium, brass and manual oxygen cutting and flame gouging.

The combined sections would cover the needs of general engineering industry for manufacture and maintenance work.

13.1.1 The exercises prescribed in the two different sections shall be performed on mild steel, cast iron, aluminium and brass, on the thicknesses appropriate to each individual exercise. The plates used shall be reasonably free from extraneous matter, such as rust, scales, paint, etc, and defects which adversely affect welding. For execution of each exercise, the trainee shall have a welding unit for his exclusive use.

13.1.2 The importance of maintaining the correct flame characteristics as applicable to welding of different metals to obtain welds of uniformly good quality and the importance of proper cleanliness, joint preparation, blow pipe and rod angles and the use of fluxes (where necessary) shall be emphasized during each exercise.

13.1.3 After completing each group of exercises the trainee shall be required to pass the check tests prescribed for that group, designed to demonstrate whether he has acquired a satisfactory degree of skill in the techniques covered by that group of exercises.

13.1.4 Detailed suggestions covering each section and group of exercises are given in Appendix F.

14. EXERCISES — SECTION I WELDING OF MILD STEEL SHEETS UP TO 3·15 mm IN THICKNESS AND TUBES UP TO 60 mm IN DIAMETER AND WALL THICKNESS UP TO 1·60 mm

14.0 Welding exercises in these groups shall be carried out with a neutral flame.

14.1 Exercises in Section I — Group A

14.1.1 *Fitting up of Equipment, Adjustment of Flame and Deposition of Weld Beads* — Exercises in Group A shall be designed to instruct the trainee to fit up the equipment, set the gas pressures, to light and adjust the flame and to deposit beads of correct width and build-up with 1·60 mm diameter mild steel filler rods and to make butt welds in 1·60 mm mild steel sheet in flat position. The following exercises shall be included in this group:

a) Fitting up of equipment and adjustment of gas pressures;

b) Lighting and adjustment of the flame — neutral, oxidizing (excess oxygen) and reducing (excess acetylene) flames (*see* Fig. 2, 3 and 4); and

NOTE — The maintenance of a constant flame at the desired adjustment is most important. Generally, for steel the flame should be neutral, that is the inner cone should be sharply defined with a very slight haze or flicker at the end of it. This haze or flicker provides an 'indicator', which by its disappearance will show when the flame is tending to become oxidizing (*see* Fig. 3).

c) Bead welds without and with filler rods in flat position.

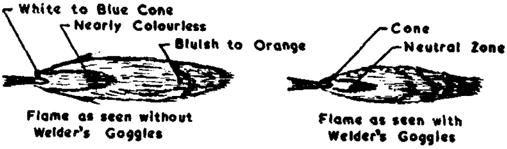

White to Blue Cone
Nearly Colourless
Bluish to Orange
Flame as seen without Welder's Goggles
Cone
Neutral Zone
Flame as seen with Welder's Goggles

FIG. 2 NEUTRAL FLAME

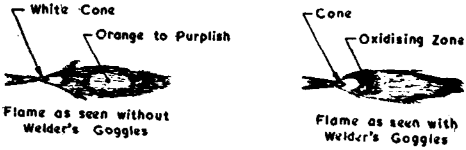

White Cone
Orange to Purplish
Flame as seen without Welder's Goggles
Cone
Oxidising Zone
Flame as seen with Welder's Goggles

FIG. 3 OXIDIZING FLAME

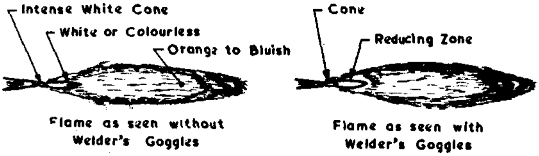

Intense White Cone
White or Colourless
Orange to Bluish
Flame as seen without Welder's Goggles
Cone
Reducing Zone
Flame as seen with Welder's Goggles

FIG. 4 REDUCING FLAME

The exercises in Group A shall be performed by the forward welding technique (*see* Fig. 5).

14.1.2 *Check Tests on Exercises in Section I — Group A* — No specific tests are prescribed for this group. The trainee shall be able to adjust the flame to the three different conditions. He shall be able to deposit beads with or without filler rods. The bead welds made with a filler rod shall be straight and have even build-up free from undercutting and shall not show presence of oxidation or burning.

14.2 Exercises in Section I — Group B

14.2.1 The exercises in Group B shall be designed to instruct the trainee in the technique of making butt welds in 1·60 mm mild steel plates in flat

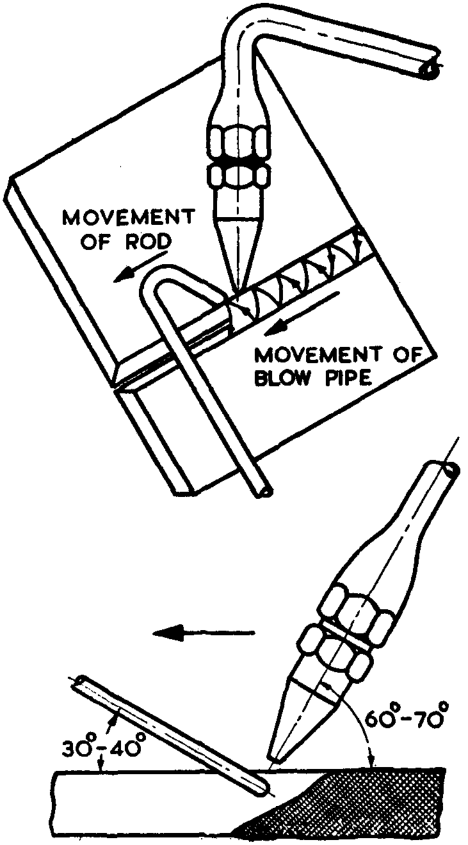
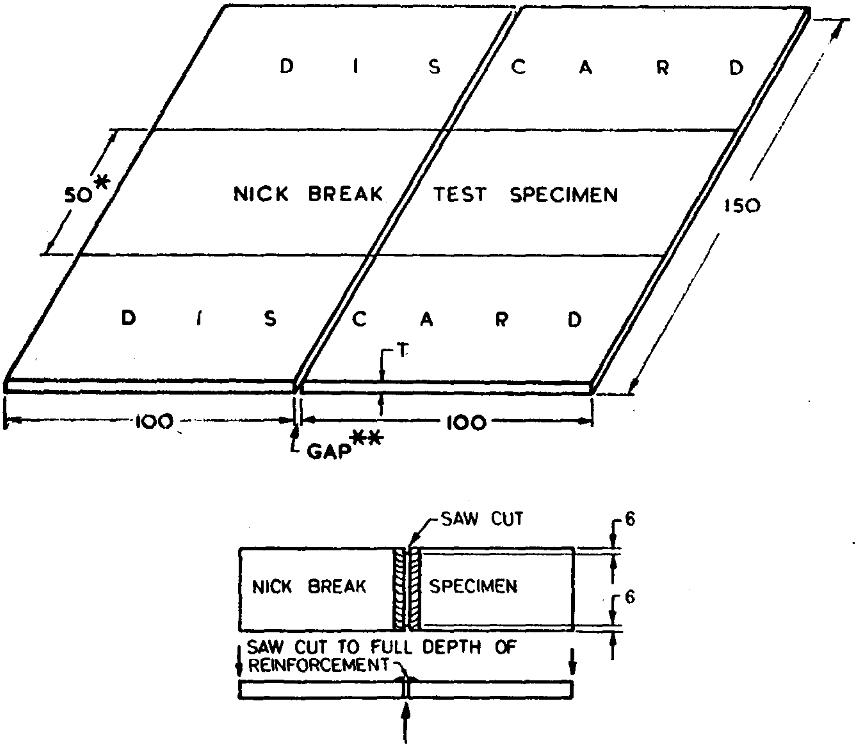


FIG. 5 FORWARD WELDING

and vertical positions and in 3·15 mm thick plates in flat position. Exercises on the following types of welds shall be included in this group; which shall be performed by forward technique:

Weld	Edge Preparation
a) Butt welds in 1·60 mm mild steel plate in flat position b) Butt welds in 1·60 mm mild steel plate in vertical position (vertical upward) c) Butt welds in 3·15 mm thick plates in flat position	*see* Fig. 6



*Weld to be stopped and restarted within central 50 mm of run. Specimen to be tested by nick breaking.

**Gap T/2 for flat position, and T for vertical position, where T is the thickness of specimen.

All dimensions in millimetres.

Fig. 6 Butt Weld Specimen

14.2.2 *Check Tests on Exercises in Section I — Group B* — The trainee shall be required to make three check test specimens conforming to the requirements stated in Table I.

TABLE I SPECIMEN WELDS FOR CHECK TESTS ON EXERCISES IN SECTION I — GROUP B

SPECIMEN No. (1)	DESCRIPTION OF JOINT (2)	WELDING POSITION (3)	JOINT PREPARATION AND OTHER DETAILS (4)	PROCEDURE FOR WELDING (5)
1	Butt weld in 1·60 mm mild steel sheet	Flat	Fig. 6	Weld to be made in a single run with 1·60 mm diameter filler rod
2	,,	Vertical	Fig. 6	Weld to be made in a single run with 1·60 mm diameter filler rod (upward method)
3	Butt weld in 3·15 mm mild steel sheet	Flat	Fig. 6	Weld to be made in a single run with 3·15 mm diameter filler rod

NOTE — Forward welding technique is to be employed and no back sealing run is to be permitted.

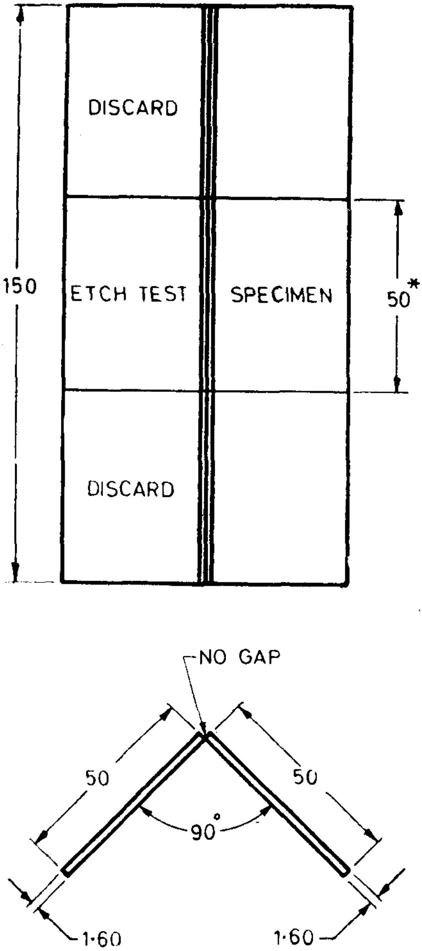
14.2.3 Each weld shall be inspected, visually for surface appearance and condition, penetration, size and contour checked with a suitable weld gauge, and then ruptured for internal examination. Each weld shall be assessed on the basis of provisions given under **16**.

14.3 Exercises in Section I — Group C

14.3.1 The exercises in Group C shall be designed to instruct the trainee in the technique of making butt welds in 3·15 mm mild steel plates in vertical position, corner welds in 1·60 mm mild steel plates in flat and vertical positions and fillet welds in 1·60 mm mild steel plates in horizontal-vertical position. Exercises on the following types of welds shall be included in this group:

WELD	EDGE PREPARATION
a) Butt welds in 3·15 mm mild steel sheet in vertical position	Fig. 6
b) Corner welds in 1·60 mm mild steel sheet in flat position	Fig. 7

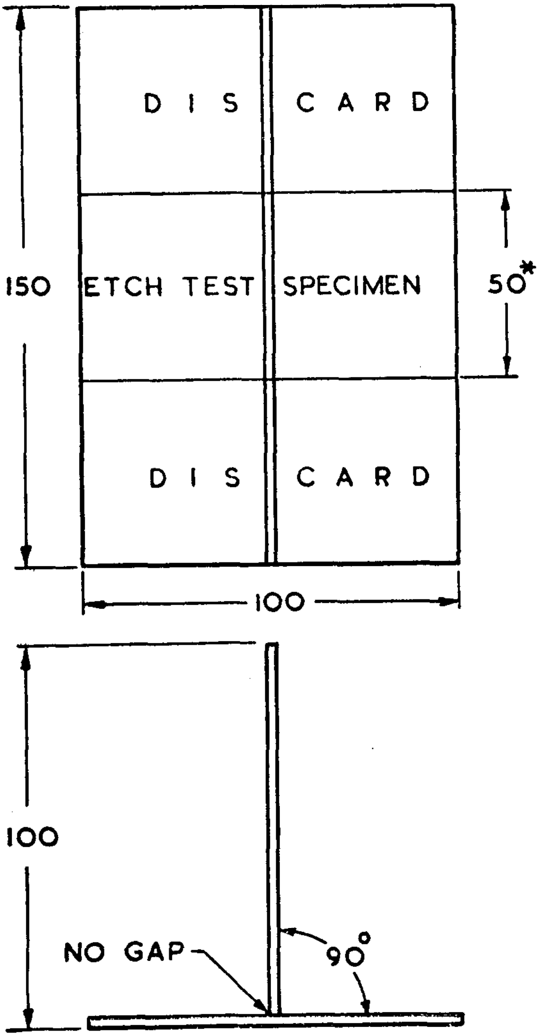
WELD	EDGE PREPARATION
c) Corner welds in 1·60 mm mild steel sheet in vertical position	Fig. 7
d) Fillet weld in 1·60 mm mild steel sheet in horizontal-vertical position	Fig. 8



*Weld to be stopped and restarted within central 50 mm of run. Specimen to be cut and etched.

All dimensions in millimetres.

FIG. 7 CORNER WELD SPECIMEN



*Weld to be stopped and restarted within central 50 mm of run. Specimen to be cut and etched.

All dimensions in millimetres.

FIG. 8 FILLET WELD SPECIMEN; HORIZONTAL-VERTICAL POSITION

14.3.2 *Check Tests on Exercises in Section I — Group C* — The trainee shall be required to make three specimen welds conforming to the requirements stated in Table II.

TABLE II SPECIMEN WELDS FOR CHECK TEST ON EXERCISES IN SECTION I — GROUP C

SPECIMEN No. (1)	DESCRIPTION OF JOINT (2)	WELDING POSITION (3)	JOINT PREPARATION AND OTHER DETAILS (4)	PROCEDURE FOR WELDING (5)
4	Butt weld in 3·15 mm mild steel sheet	Vertical	Fig. 6	Weld to be made in a single run with 2·50 mm or 1·60 mm diameter filler rod (upward method)
5	Corner weld in 1·60 mm mild steel sheet	Flat	Fig. 7	Weld to be made in a single run with 1·60 mm diameter filler rod
6	Corner weld in 1·60 mm mild steel sheet	Vertical	Fig. 7	Weld to be made in a single run with 1·60 mm diameter filler rod (upward method)
7	Fillet weld in 1·60 mm mild steel sheet	Horizontal-vertical	Fig. 8	Weld to be made in a single run with 1·60 mm diameter filler rod

NOTE — Forward welding technique is to be employed and in the case of butt and corner welds no back sealing run shall be permitted.

14.3.3 Each weld shall be inspected visually for surface appearance and condition, penetration, size and contour checked with a suitable gauge and then ruptured for internal examination. Each weld shall be assessed on the basis of provisions given under **16**.

14.4 Exercises in Section I — Group D

14.4.1 The exercises in Group D shall be designed to instruct the trainee in the technique of making welds in thin-walled mild steel tubes — butt welds, branch joints and tube-to-plate joints in downhand position. Exercises on the following types of welds shall be included in this group.

WELD	EDGE PREPARATION
a) Butt weld in 25 mm outside diameter, 1·60 mm wall thickness tubes in flat position, turning through 180°	Fig. 9

WELD	EDGE PREPARATION
b) Welds of branch joints in 25 mm outside diameter tube, 1·60 mm wall thickness, angles 90° and 45° in flat position — turning the assembly through 180°	Fig. 10
c) Welds in sheet to tube (fillet) — sheet 1·60 mm, tube 25 mm outside diameter, wall thickness 1·60 mm, angles 90° and 45° in horizontal-vertical position	Fig. 11

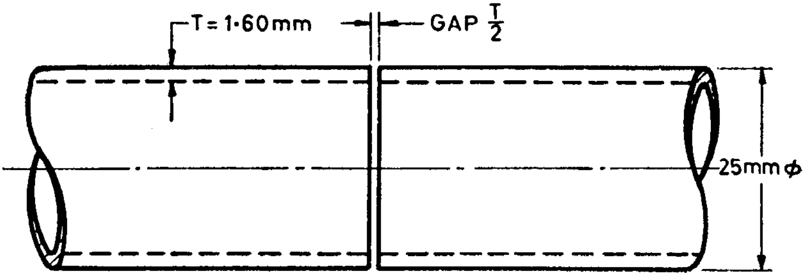
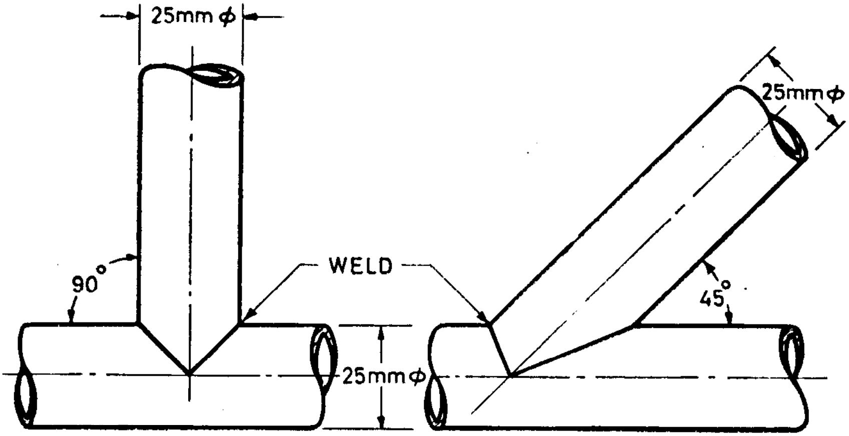


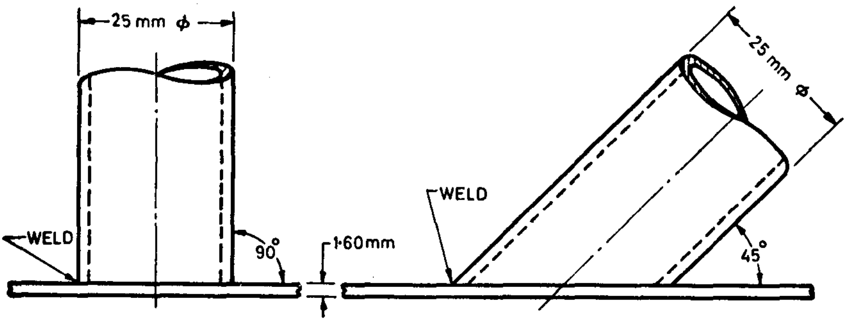
FIG. 9 BUTT WELD OF TUBE ENDS



10A 90° Angle 10B 45° Angle

FIG. 10 BRANCH JOINTS IN TUBES

14.4.2 *Check Tests on Exercises in Section I — Group D* — The trainees shall be required to make two test specimen welds conforming to the requirements stated in Table III.



A11 90° Angle 11B 45° Angle

FIG. 11 TUBE-TO-SHEET JOINTS

TABLE III SPECIMEN WELDS FOR CHECK TEST ON EXERCISES IN SECTION I — GROUP D

(*Clause* 14.4.2)

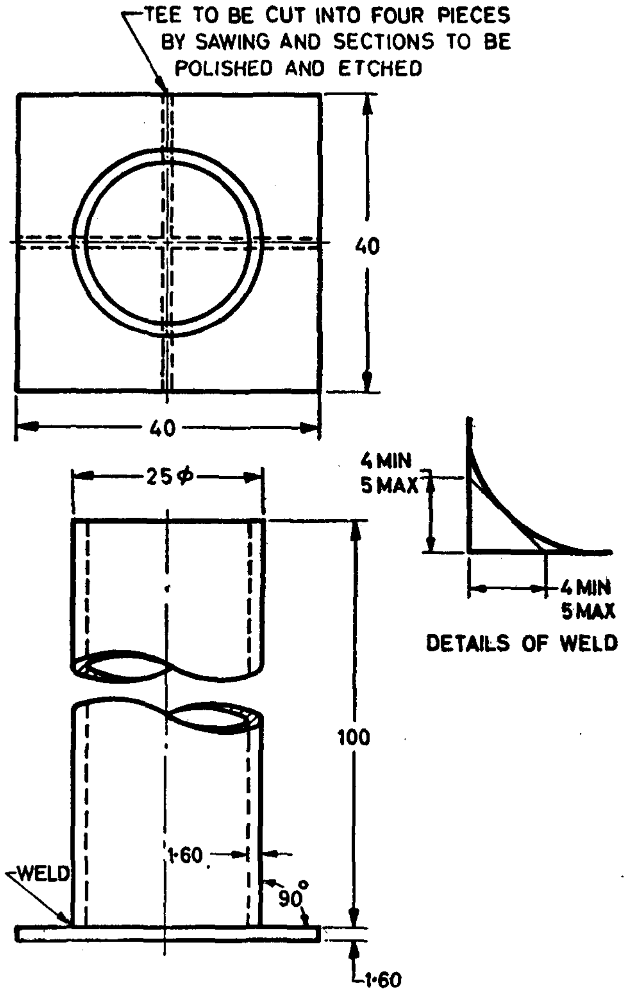
SPECIMEN No.	DESCRIPTION OF JOINT	WELDING POSITION	JOINT PREPARATION AND OTHER DETAILS	PROCEDURE FOR WELDING
(1)	(2)	(3)	(4)	(5)
8	Tube — 25 mm outside diameter, 1·60 mm wall thickness to sheet 1·60 mm thick — angle 90°	Horizontal-vertical	Fig. 12	Weld as specified in Fig. 12 to be made with 1·60 mm diameter filler rod in one pass
9	Tube to Tube — Branch Joints	Flat and horizontal-vertical	Fig. 13	Welds as specified in Fig. 13 to be made with 1·60 mm diameter filler rods in one pass. The assembly may be turned through 180°

NOTE — Forward welding technique is to be employed.

14.4.3 Each weld shall be inspected visually for surface appearance and condition, size and contour checked with a suitable gauge, and then sectioned for internal examination. Each weld shall be assessed on the basis of provisions given under **16**.

15. EXERCISES — SECTION II WELDING OF CAST IRON, ALUMINIUM, BRASS AND MANUAL OXYGEN CUTTING AND FLAME GOUGING

15.0 Exercises in this section are extensions of those in Section I, covering welding of aluminium, brass and cast iron (fusion and braze


TEE TO BE CUT INTO FOUR PIECES BY SAWING AND SECTIONS TO BE POLISHED AND ETCHED
40
40
25 ϕ
4 MIN
5 MAX
4 MIN
5 MAX
DETAILS OF WELD
100
WELD
1·60
90°
1·60

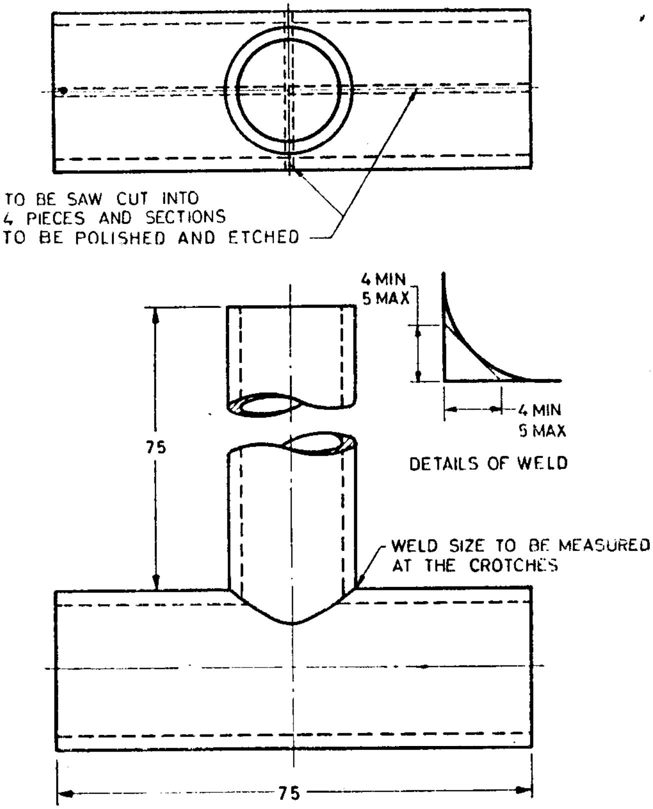
All dimensions in millimetres.

FIG. 12 WELD SPECIMEN OF TUBE-TO-SHEET JOINT

welding) and manual oxygen cutting and flame gouging. This section is intended for the trainee who is able to complete successfully the course of training scheduled in Section I.

15.1 Exercises in Section II — Group E

15.1.1 The exercises in Group E shall be designed to instruct the trainee in the techniques of making butt welds in pure aluminium and brass sheets


TO BE SAW CUT INTO 4 PIECES AND SECTIONS TO BE POLISHED AND ETCHED
4 MIN 5 MAX
4 MIN 5 MAX
DETAILS OF WELD
75
WELD SIZE TO BE MEASURED AT THE CROTCHES
75

All dimensions in millimetres.

FIG. 13 WELD SPECIMEN OF TUBE-TO-TUBE BRANCH JOINT

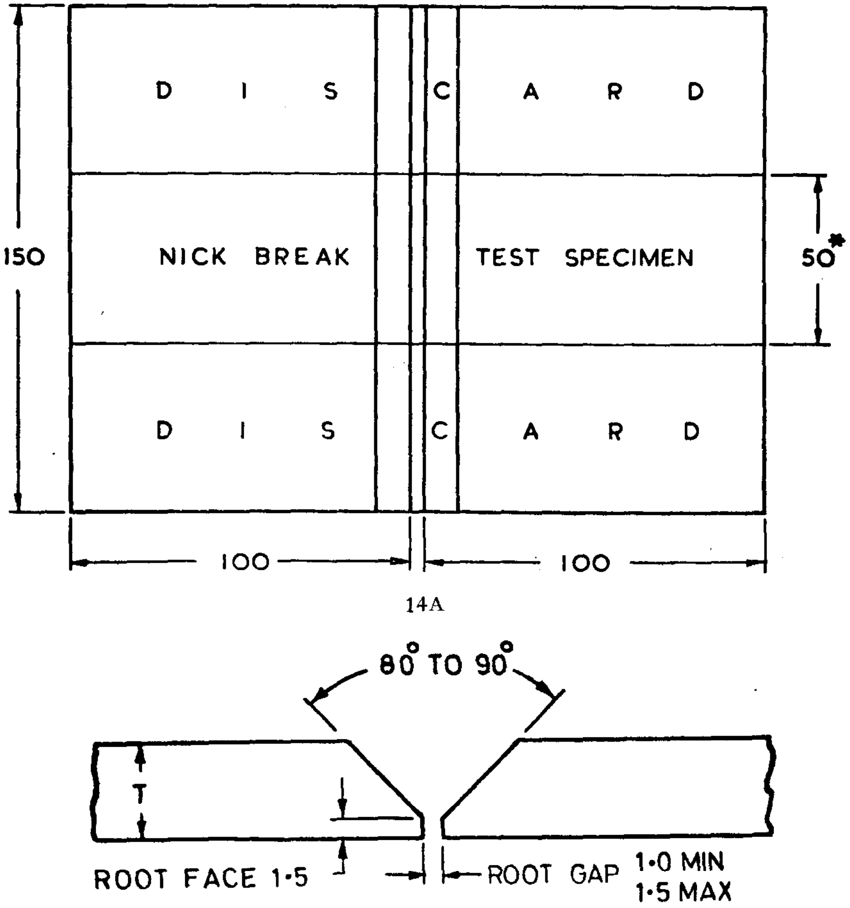
up to a thickness of 3·15 mm. The following types of welds shall be included in this group:

WELD	EDGE PREPARATION
a) Butt welds in 1·60 mm thick pure aluminium sheets in flat position	Fig. 6
b) Butt welds in 3·15 mm thick pure aluminium sheets in flat position	Fig. 14
c) Butt welds in 1·60 mm thick brass sheets in flat position	Fig. 6

WELD	EDGE PREPARATION
d) Butt welds in 3·15 mm thick brass sheets in flat position	Fig. 14

NOTE — Flame conditions:

For aluminium — neutral with a slight haze of excess acetylene, and
For brass — oxidizing.



14A

14B

*Weld to be stopped and restarted within central 50 mm run. Specimen to be cut and nick broken.

All dimensions in millimetres.

FIG. 14 BUTT WELD SPECIMEN IN ALUMINIUM OR BRASS SHEET

15.1.2 *Check Tests on Exercises in Section II — Group E* — The trainee shall be required to make two test specimen welds conforming to the requirements in Table IV.

TABLE IV SPECIMEN WELDS FOR CHECK TEST ON EXERCISES IN SECTION II — GROUP E

Specimen No.	Description of Joint	Welding Position	Joint Preparation and Other Details	Procedure for Welding
(1)	(2)	(3)	(4)	(5)
10	Butt weld in 3·15 mm thick pure aluminium sheet	Flat	Fig. 14	Weld to be made in a single run with 3·15 mm diameter filler rod
11	Butt weld in 3·15 mm thick brass sheet	Flat	Fig. 14	Weld to be made in a single run with 3·15 mm diameter filler rod

NOTE — Forward welding technique is to be employed and no back sealing run is to be permitted.

15.1.3 Each weld shall be inspected visually for surface appearance and condition, penetration, size and contour checked with a suitable gauge, and then ruptured for internal examination. Each weld shall be assessed on the basis of provisions given under **16**.

15.2 Exercises in Section II — Group F

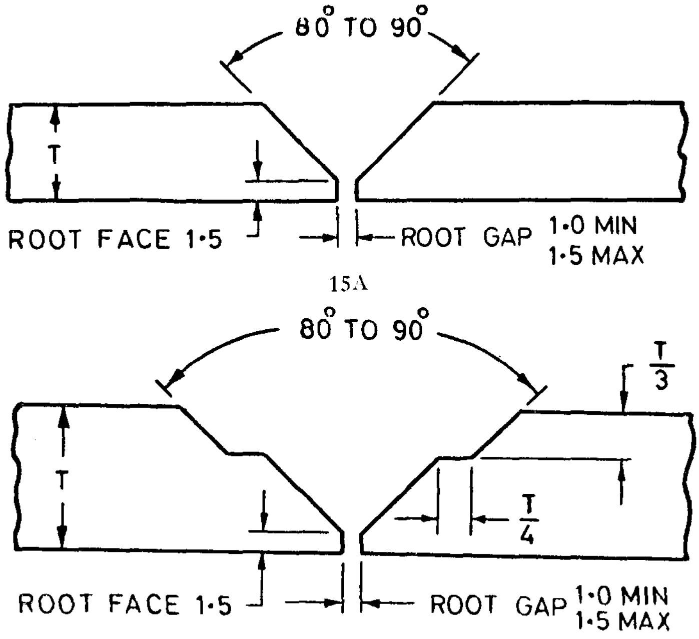
15.2.1 Exercises in this group shall be designed to instruct the trainee in the technique of making butt welds in cast iron by the fusion and braze welding technique in flat position. The following types of welds shall be included in this group:

Weld	Edge Preparation
a) Butt welds in cast iron plates 10 mm and 12 mm thick in flat position by the fusion technique	Fig. 15(A)
b) Butt welds in cast iron plates 10 mm and 12 mm thick in flat position by the braze welding technique	Fig. 15(A) or Fig. 15(B)

NOTE — Flame conditions:

For fusion welding — strictly neutral, and
For braze welding — slightly oxidizing.

15.2.2 *Check Tests on Exercises in Section II — Group F* — The trainee shall be required to make two test specimen welds conforming to the requirements stated in Table V.



15A

15B

NOTE — All corners rounded.

All dimensions in millimetres.

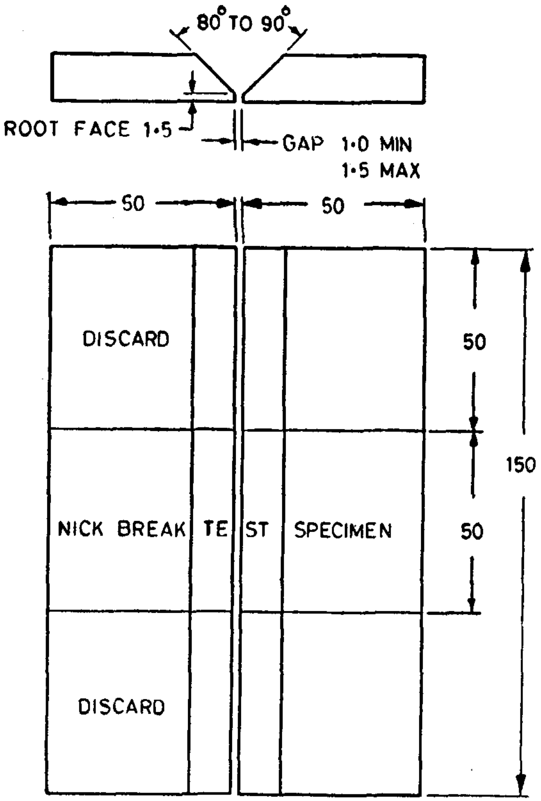
FIG. 15 BUTT WELD IN CAST IRON PLATE

TABLE V SPECIMEN WELDS FOR CHECK TEST ON EXERCISES IN SECTION II — GROUP F

(*Clause* 15.2.2)

SPECIMEN No.	DESCRIPTION OF JOINT	WELDING POSITION	JOINT PREPARATION AND OTHER DETAILS	PROCEDURE FOR WELDING
(1)	(2)	(3)	(4)	(5)
12	Butt weld in cast iron plate 12 mm thick by the fusion technique	Flat	Fig. 15(A) and Fig. 16	Weld to be made with 6 mm diameter filler rod
13	Butt weld in cast iron plate 10 mm thick by the braze welding technique	Flat	Fig. 15(A) or Fig. 15(B) and Fig. 16	Weld to be made with 5 mm diameter filler rod

NOTE — Forward welding technique is to be used and no back sealing run is to be permitted.



All dimensions in millimetres.

FIG. 16 BUTT WELD SPECIMEN IN CAST IRON PLATE

15.2.3 Each weld shall be inspected visually for surface appearance and condition, penetration, size and contour checked with a suitable gauge, and then ruptured for internal examination. Each weld shall be assessed on the basis of provisions given under **16**.

15.3 Exercises in Section II — Group G

15.3.1 Exercises in this group shall be designed to instruct the trainee in the technique of making butt welds in cast iron by the braze welding technique in vertical position and depositing hardfacing rods on mild steel in flat position. The following types of welds shall be included in this group:

	WELD	EDGE PREPARATION
a)	Butt welds in cast iron plates 10 mm and 12 mm thick in vertical position by braze welding technique	Fig. 15(A) or Fig. 15(B)
b)	Depositing hardfacing rods on 10 mm thick plates in flat position (plate preparation, flame condition, etc, according to the directions of the makers of the rod)	—

15.3.2 *Check Tests on Exercises in Section II — Group G* — The trainee shall be required to make one test specimen weld conforming to the requirements stated in Table VI.

TABLE VI SPECIMEN WELD FOR CHECK TEST ON EXERCISES IN SECTION II — GROUP G

SPECIMEN No.	DESCRIPTION OF JOINT	WELDING POSITION	JOINT PREPARATION AND OTHER DETAILS	PROCEDURE FOR WELDING
(1)	(2)	(3)	(4)	(5)
14	Butt weld in cast iron plate 10 mm thick by the braze welding technique	Vertical	Fig. 15(A), or Fig. 15(B) and Fig. 16	Weld to be made with 5 mm rod (upward method)

NOTE — No specific test is prescribed for testing the trainee on hardfacing.

15.3.3 The weld shall be inspected visually for surface appearance and condition, penetration, size and contour checked with a suitable gauge, and then ruptured for internal examination. Each weld shall be assessed on the basis of provisions given under **16**.

15.4 Exercises in Section II — Group H

15.4.1 Exercises in this group shall be designed to instruct the trainee in manual oxygen cutting and flame gouging. The following exercises shall be included in this group:

a) The trainee shall receive training in the handling and operation of hand-cutting blow pipe, in cutting plates and sections and in piercing holes in plates; and

b) The trainee shall receive training in the handling and operation of flame-gouging blow pipe, in making grooves on plates, in the removal of welds and in rivet cutting.

15.4.2 *Check Test on Exercises in Section II — Group H* — The trainee shall be required to make two test specimens conforming to the requirements stated in Table VII.

TABLE VII SPECIMEN FOR CHECK TEST ON EXERCISES IN SECTION II — GROUP H

Specimen No.	Description of Work
15	A 75-mm square to be cut in the centre of a plate of size 150 mm × 150 mm and 12 mm thick
16	A fillet weld to be removed from a tee joint

15.4.3 The test specimens are to be assessed as under:

a) *Manual Cutting* — The ability of the trainee to start the cut by piercing a hole and to make a reasonably clean cut following the profile as nearly as possible bearing in mind the limitations of manual oxygen cutting.

b) *Flame Gouging* — The ability of the trainee to remove the weld without damaging the plates.

15.4.4 If the trainee successfully performs these two check tests (*see* **15.4.2**), he should be deemed to have qualified for manual oxygen cutting and flame gouging, initial qualification tests.

16. ASSESSMENT OF CHECK TEST WELDS IN SECTIONS I AND II

16.0 In the assessment of the check test welds, the factors given under **16.1** and **16.2** shall receive consideration.

16.1 Inspection Before Fracture

16.1.1 *Factor* 1 — *Dimensions of Weld Deposit* — The dimensions of the weld shall be checked. The size of the weld shall be as specified and it may be slightly over but not under.

16.1.2 *Factor* 2 — *Shape of Profile* — The profile of the weld is affected by the position of the joint, but it shall be uniform. In the case of butt and corner welds, the profile shall be slightly convex and in the case of fillet weld, it is usually slightly concave.

16.1.3 *Factor* 3 — *Uniformity of Surface* — The height and spacing of the ripples shall be uniform, these being indicative of the quality of workmanship.

16.1.4 *Factor* 4 — *Degree of Undercut* — Undercutting is undesirable. The weld joint shall be free from undercut but slight intermittent occurrences may be disregarded.

16.1.5 *Factor* 5 — *Smoothness of Joints Where Welding is Recommended* — The joints in the weld run, where welding has been recommended, shall be as smooth as possible and shall show no pronounced hump or crater in the weld surface.

16.1.6 *Factor* 6 — *Freedom from Surface Defects* — The surface of the weld shall be free from porosity, cavities and burnt-on scale.

16.1.7 *Factor* 7 — *Penetration Bead in Butt Welds* — A slight penetration bead shall be present and it should be reasonably uniform in width and appearance. Occasional occurrences of lack of penetration bead may be disregarded.

16.2 Inspection of Etched Sections and Weld Fractures — Inspection of etched sections and weld fractures gives information concerning degree of fusion, degree of root penetration, gas cavities and quality of weld metal.

16.2.1 *Factor* 8 — *Degree of Fusion* — Fusion shall be complete over the whole area of the joint surface.

16.2.2 *Factor* 9 — *Degree of Root Penetration, Butt and Fillet Welds* — Defects are most likely to occur at the root of the weld and, in this position, they are liable to have the maximum effect in reducing the strength of the weld. A close examination of the root shall, therefore, be made. In butt welds, the penetration should extend to the underside of the plates producing a penetration bead of the right size. In fillet welds with good root penetration the weld metal should reach the corner.

NOTE 1 — In tube to tube branch joints, both butt and fillet welds will appear in a joint, fillets being at the crotches.

NOTE 2 — In case of welding of cast iron by the braze welding technique, the joint shall show satisfactory penetration and adhesion.

16.2.3 *Factor* 10 — *Gas Cavities and Inclusions* — Unless they are caused by the use of unsuitable material, they are attributable to the quality of workmanship, the desired result being to achieve uniform appearance and freedom from cavities and flux entrapments (where flux is used). In fusion welding of mild steel, cast iron and aluminium where neutral flame is used, and in fusion welding of brass or braze welding of cast iron where oxidizing flame is used, incorrect welding technique may result in rough porous, discoloured and lustreless appearance in the fracture.

NOTE — In case of fusion welding or braze welding of cast iron, isolated blowholes or concentration of pinholes in the weld metal shall be regarded as grounds for rejection but isolated pinholes shall not be so regarded.

17. INSTRUCTION IN WELDING THEORY

17.1 General — Each trainee shall receive training in subjects related to the theory of welding for at least 50 hours, that is 25 hours each for Sections I and II (*see* **6.2**). The instructor shall be responsible for seeing that each trainee acquires a satisfactory knowledge of the subjects covered in the course. The instruction, when possible, shall be supplemented by films or other visual aids.

17.2 Safety in Welding — The instruction course shall be so designed as to make the trainee aware of the necessity for observing the safety precautions under the following three general headings:

a) *Protection of Person,* that is, proper footwear, clothing, goggles with proper shade of lens, adequate ventilation, etc.

b) *Protection of Property,* that is, safeguarding combustible material, protection from flying sparks and flame, availability of fire protection equipment, etc.

c) *Protection and Care of Equipment,* that is, storage and handling of oxygen and acetylene cylinders, carbide and acetylene generator (where low pressure system is used), operation of pressure regulators, handling of blow pipe, care of hose and hose connections, welding tips, etc.

17.2.1 The instruction in safety shall be given before the trainee is permitted to use any welding equipment. A list of recommended rules of safety is given in Appendix G and should be used in this instruction.

17.2.2 For detailed instructions for safety and health requirements in welding and cutting operations, reference should be made to IS: 818-1957 Code of Practice for Safety and Health Requirements in Electric and Gas Welding and Cutting Operations.

17.3 Welding Equipment — Instructions in this subject shall be designed to instruct the trainee in the principles of blow pipe and regulator design and functional aspects, in fitting and dismantling equipment (not stripping down into various components), flame adjustment, care of equipment, etc.

17.4 Welding Techniques — Instructions in this subject shall be designed to instruct the trainee in the various welding techniques — forward, rightward or backward, all-position rightward, vertical and double operator vertical, flames to be used for welding various metals and alloys, selection of correct size of tips to be used, edge preparation, etc.

17.5 Welding Terms and Symbols — Instructions in these subjects shall be designed to acquaint the trainee with the more important terms relating to oxy-acetylene welding and the standard symbols used for detailing welds and weld sizes on drawings. The instructions in welding terms and symbols should be based on IS: 812-1957 and IS: 813-1956 respectively.

17.6 Welding Metallurgy — Steel Only (With Special Reference to Sheet Metal Welding) — Instructions in this subject shall be designed to give the trainee an elementary knowledge of the metallurgical and thermal factors in the welding of steel, with particular reference to welding of sheet metal.

17.7 Welding Metallurgy — Cast Iron, Aluminium, Brass and Bronze — Instructions in this subject shall be designed to give the trainee an elementary knowledge of the metallurgical and thermal factors in the welding of these metals, their special welding techniques, limitations, post-weld treatment, flux residue removal treatment, etc.

17.8 Welding of Castings — Instructions in this subject shall be designed to give the trainee a knowledge on the techniques of welding castings — ferrous and non-ferrous metals, the object and necessity for pre- and post-heating, methods of preparation of fracture, etc.

17.9 Hardfacing — Instructions in this subject shall be designed to give the trainee an elementary knowledge of different types of hardfacing rods and their applications, preparation for hardfacing, etc.

17.10 Oxygen Cutting — Instructions in this subject shall be designed to give the trainee an elementary knowledge of the principles of oxygen cutting, effects of different elements in steel on cutting, precautions to be taken in cutting alloy steels, etc.

17.11 Inspection and Testing of Welds — Instructions in this subject shall be designed to acquaint the trainee with the more common methods of weld inspection and testing, as applied to welds made both in the shop and in the field, and may be given in the form of a discussion of the trainee's welds before and after testing. The instructor shall point out such factors as may have caused defects in the specimen. In the overall study of this subject, destructive and non-destructive methods of testing shall be covered.

17.11.1 For inspection of welds, reference should be made to *IS: 822- Code of Practice for Inspection of Welds.

17.12 Characteristics of Filler Rods — Instructions in this subject shall be designed to familiarize the trainee with the different types of filler rods used in oxy-acetylene welding.

17.13 Costing — Instructions in this subject shall include a study of elements of estimating material requirements and factors affecting welding cost.

17.14 Possibilities and Limitations of Welding — The trainee shall, through discussions and demonstrations, be given an appreciation of the limitations and possibilities of oxy-acetylene welding.

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*Under preparation.

PART IV TESTS FOR WELDERS

18. GENERAL

18.1 These tests shall be of the following three types:

a) Initial qualification test,
b) Annual test, and
c) Periodic control test.

18.2 These tests are designed to show that the welder is familiar with the usual welding techniques. Approval of welders for works of special nature may demand additional special trade or approval tests.

18.3 Annual tests and periodic control tests are to be done by the employers, as required.

19. INITIAL QUALIFICATION TESTS

19.0 General — The initial qualification tests shall be conducted after the trainee has completed all the requirements prescribed in Part III of this code. The initial qualification tests would comprise of eight tests. The details of test pieces and test procedures for these tests shall be as given under **19.1** to **19.8**.

19.1 Test No. 1 — Oxy-Acetylene Butt Welds in Mild Steel Plate 3·15 mm Thick

19.1.1 *Parent Metal* — The parent metal shall be as specified in the code.

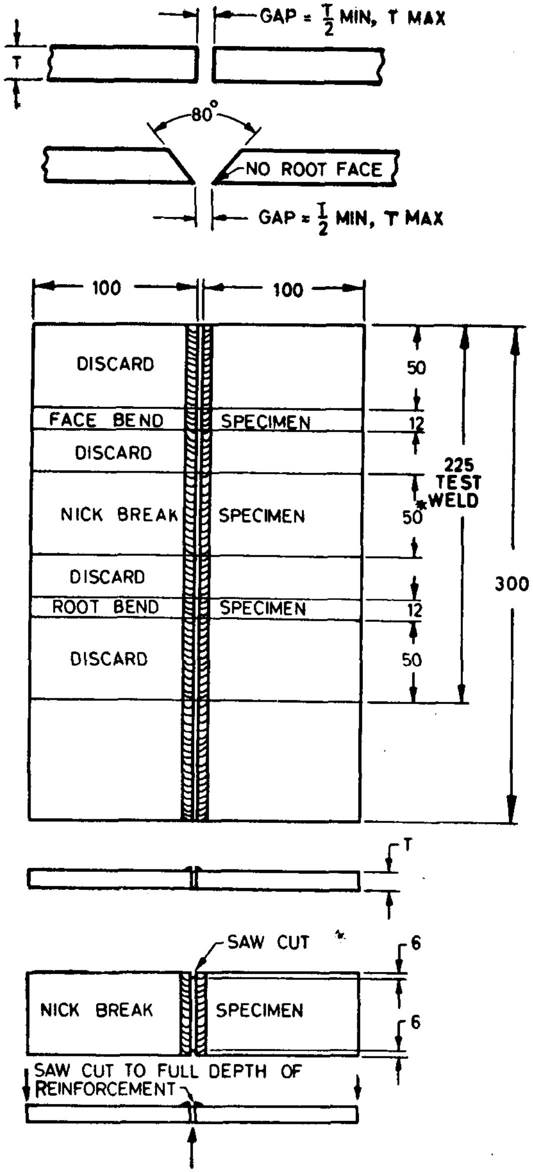
19.1.2 *Position* — The test welds shall be deposited in the appropriate position as follows:

Flat	(slope 0°, rotation 0°)
Vertical	(slope 90°)

19.1.3 *Assembly for Welding* — The test piece shall conform to the requirements of Fig. 17. The joints shall be prepared as below:

Edges	Square or single V (included angle 80° and no root face)
Gap	Not less than half the plate thickness but not more than the plate thickness

The plate edges may be prepared by shearing, machining, grinding or filing. Tack welds shall be on the side to be welded and in line of the weld. No other method of restraint shall be used. Distortion or misalignment caused by tacking may be corrected before the test weld is deposited. The test piece shall be supported in such a manner that contact with the bench or other material does not provide a backing for joint.



*Weld to be stopped and restarted within central 50 mm of run.

All dimensions in millimetres.

FIG. 17 OXY-ACETYLENE BUTT WELDS IN MILD STEEL PLATE 3·15 mm THICK

19.1.4 *Filler Rod* — The filler rod used shall be 3·15 mm in diameter, but for welding in vertical position lesser diameter rod but not less than 1·60 mm in diameter may be used. The type of filler rod as stipulated in the code shall be used.

19.1.5 *Depositing the Test Weld* — The test weld shall be 225 mm long as shown in Fig. 17. The weld shall be deposited in a single run using the appropriate method as follows:

POSITION	METHOD
Flat	Forward
Vertical	Forward (Vertical upward)

The weld shall be stopped and started within the central 50 mm of the run. A sealing run on the reverse side is not permitted, so that the degree of root penetration can be subsequently examined.

19.1.6 *Assessment*

19.1.6.1 *Visual examination* — The weld shall be visually examined for dimension of deposit, shape of profile, uniformity of surface, degree of undercut, smoothness of joints, freedom from surface defects, penetration, etc, as under **16.1**.

19.1.6.2 *Destructive tests* — The test specimen shall be cut out by machining or sawing as indicated in Fig. 17 and tested as under:

a) *Etch test* — One of the cut surfaces of the test specimen shall be prepared and etched and then visually examined as under **16.1** and **16.2** (for etch test method *see* Appendix H).

b) *Bend test* — The top and underside of the two bend test specimens shall be dressed flush. When bent through 180° over a former thrice the thickness of the sheet that is 10 mm, each specimen shall show no crack or defect attributable to defective workmanship. Slight cracking at the ends of the weld metal occurring during bending may be disregarded. One specimen shall be tested with the face and the other with the root in tension.

c) *Nick break test* — The test specimen shall be notched as indicated in Fig. 17, broken open along the weld and the fractured surface visually examined as under **16.2**.

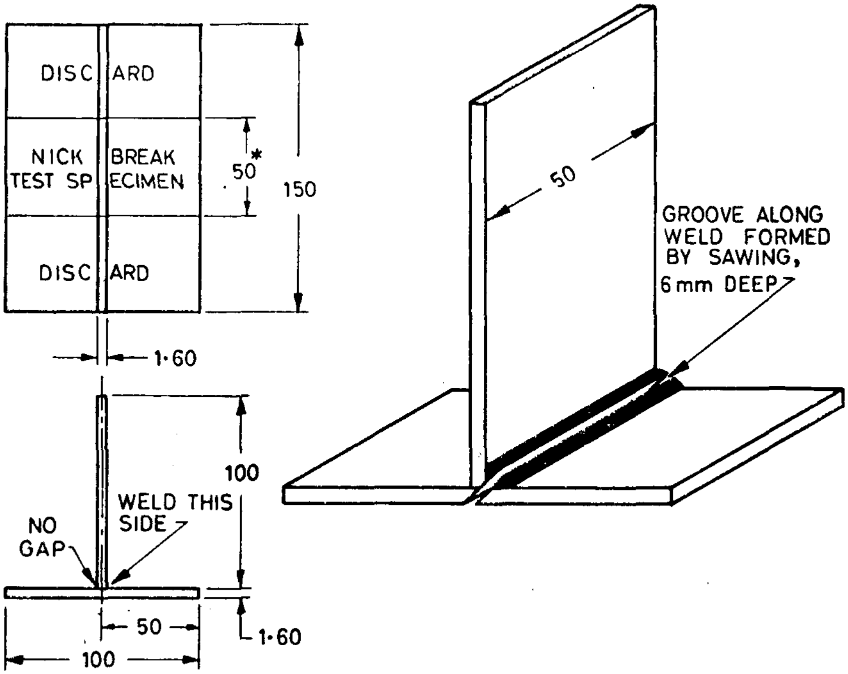
19.2 Test No. 2 Oxy-Acetylene Tee Fillet Weld in Mild Steel Sheet 1·60 mm Thick

19.2.1 *Parent Metal* — The parent metal shall be as specified in the code.

19.2.2 *Position* — The test welds shall be deposited in the appropriate position as follows:

Horizontal-vertical	(slope 0°, rotation 45°)
Vertical	(slope 90°)

19.2.3 *Assembly for Welding* — The test piece shall conform to the requirements of Fig. 18. Tack welds shall be on the side to be welded and in line of the weld. No other method of restraint shall be used. Distortion or misalignment caused by tacking may be corrected before the test weld is deposited.



*Weld to be stopped and restarted within central 50 mm of run.

All dimensions in millimetres.

FIG. 18 OXY-ACETYLENE TEE FILLET WELD IN MILD STEEL SHEET 1·60 mm THICK

19.2.4 *Filler Rod* — The filler rod used shall be 1·60 mm in diameter and of the type stipulated in the code.

19.2.5 *Deposition of the Test Weld* — The test weld shall be between 4 mm and 5 mm in size, using the appropriate method as follows:

POSITION	METHOD
Horizontal-vertical	Forward
Vertical	Forward (Vertical upward)

The weld shall be stopped and restarted within the central 50 mm of the test piece.

19.2.6 *Assessment*

19.2.6.1 *Visual examination* — The weld shall be visually examined for dimension of deposit, shape of profile, uniformity of surface, degree of undercut, smoothness of joint, freedom from surface defects, etc, as under **16.1**.

19.2.6.2 *Destructive test* — The test piece shall be cut out by machining or sawing as indicated in the figure and tested as under:

a) *Etch test* — One of the cut surfaces of the test specimen shall be prepared and etched and then visually examined as under **16.1** and **16.2** for etch test method, (*see* Appendix H).

b) *Nick break test* — The test specimen shall be notched by saw-cuts, as indicated in Fig. 18. The test piece shall then be fractured by bending to and fro until fracture occurs, when it shall be examined as under **16.2**.

19.3 Test No. 3 Oxy-Acetylene Corner Weld in Mild Steel Sheet 1·60 mm Thick

19.3.1 *Parent Metal* — The parent metal shall be as specified in the code.

19.3.2 *Position* — The test welds shall be deposited in the appropriate position as follows:

Flat	(slope 0°, rotation 0°)
Vertical	(slope 90°)

19.3.3 *Assembly for Welding* — The test piece shall conform to the requirements of Fig. 19. Tack welds, if used, shall be on the side to be welded and in line of the weld. No method of restraint shall be used. Distortion or misalignment caused by tacking may be corrected before the test weld is deposited.

19.3.4 *Filler Rod* — The filler rod used shall be 1·60 mm in diameter and of the type stipulated in the code.

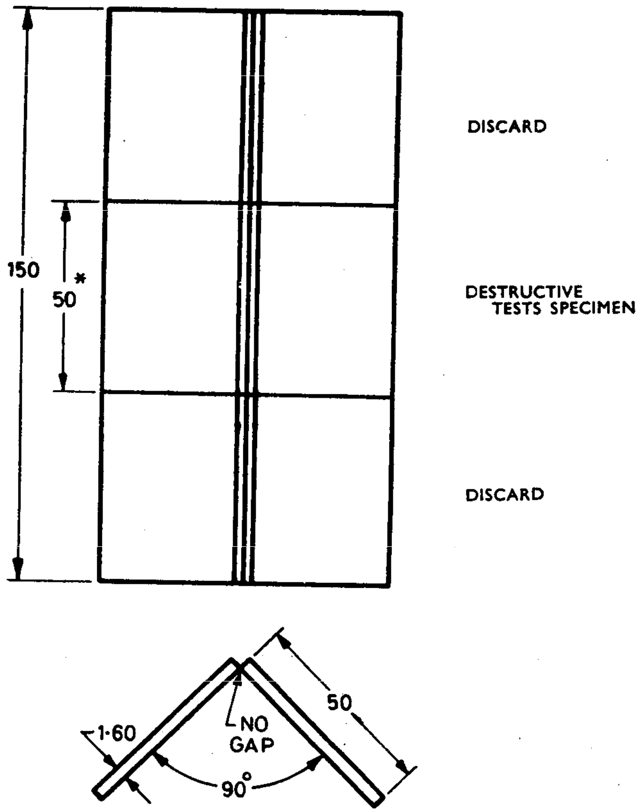
19.3.5 *Deposition of Test Weld* — The test weld shall be deposited using the appropriate method as follows:

POSITION	METHOD
Flat	Forward
Vertical	Forward (Vertical upward)

The weld shall be stopped and restarted within the central 50 mm of the test piece.

19.3.6 *Assessment*

19.3.6.1 *Visual examination* — The weld shall be visually examined for dimension of deposit, shape of profile, uniformity of surface, degree



*Weld to be stopped and restarted within central 50 mm of run. This piece to be subjected to destructive test.

All dimensions in millimetres.

FIG. 19 OXY-ACETYLENE CORNER WELD IN MILD STEEL SHEET 1·60 mm THICK

of undercut, smoothness of joints, freedom from surface defects, penetration etc, as under **16.1**.

19.3.6.2 *Destructive tests* — The test specimen shall be cut out by machining or sawing as indicated in Fig. 19 and tested as under:

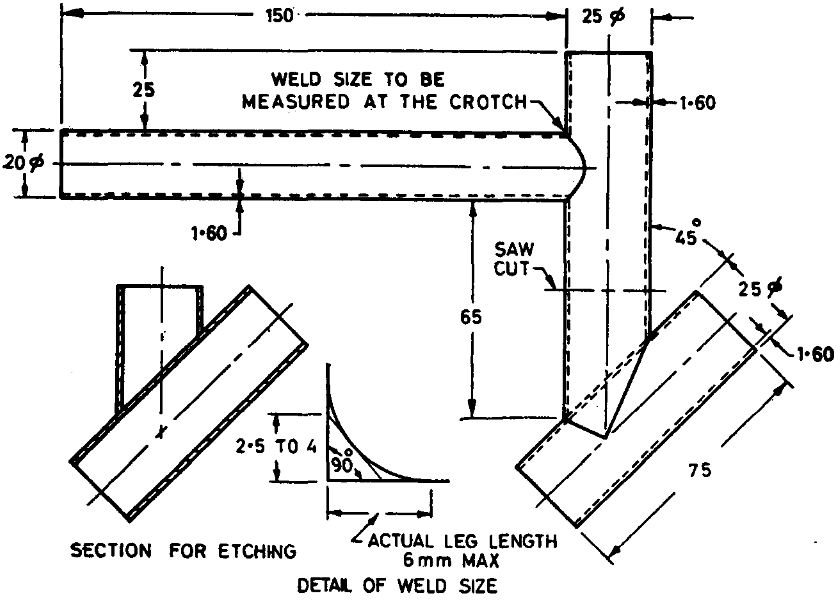
Etch test — One of the cut surfaces of the test specimen shall be prepared and etched and then visually examined as under **16.1** and **16.2**.

19.4 Test No. 4 Oxy-Acetylene Fillet Weld Branch Joints in Mild Steel Tube, Wall Thickness Up to 1·60 mm and Outside Diameter Up to 60 mm

19.4.1 *Parent Metal* — The parent metal shall be as specified in the code.

19.4.2 *Position* — The test piece may be moved into any position at the option of the trainee or the welder.

19.4.3 *Assembly for Welding* — The test piece shall be made of tubes shown in Fig. 20. The ends of the tubes at the joints shall be prepared to fit closely on outside diameter of the main tube. The tubes shall be tack welded together or held in a suitable jig.



All dimensions in millimetres.

FIG. 20 OXY-ACETYLENE FILLET WELD BRANCH JOINTS IN MILD STEEL TUBE, WALL THICKNESS UP TO 1·60 mm AND OUTSIDE DIAMETER UP TO 60 mm

19.4.4 *Filler Rod* — The filler rod used shall be 1·60 mm in diameter and of the type stipulated in the code.

19.4.5 *Deposition of Test Welds* — The test welds shall be between 2·5 mm and 4 mm size at the crotches of the right angle joints and shall be deposited using the forward method.

19.4.6 *Assessment*

19.4.6.1 *Visual examination* — The weld shall be visually examined for dimension of deposit, shape of profile, uniformity of surface, degree of undercut, smoothness of joints, freedom from surface defects, etc, as under **16.1**.

19.4.6.2 *Destructive test* — The test piece shall be cut out by machining or sawing as shown in Fig. 20 and the cut faces shall be prepared and etched and then visually examined as under **16.1** and **16.2**.

19.5 Test No. 5 Oxy-Acetylene Butt Welds in Pure Aluminium Sheet (S1A, S1B or S1C) 3·15 mm Thick

19.5.1 *Parent Metal* — The parent metal shall be as specified in the code.

19.5.2 *Position* — The test welds shall be deposited in the flat position (slope 0°, rotation 0°).

19.5.3 *Assembly for Welding* — The test piece shall conform to the requirements of Fig. 21. The plate edges may be prepared by shearing, machining or filing. The tack welds shall be on the side to be welded in the line of the weld. No other method of restraint shall be used. Distortion or misalignment caused by tacking may be corrected before the test weld is deposited. The test piece shall be supported in such a manner that contact with the bench or other material does not provide as backing for the joint.

19.5.4 *Filler Rod* — The filler rod used shall be 3·15 mm in diameter and of the type as specified in the code.

NOTE — Suitable flux should be used.

19.5.5 *Deposition of Test Weld* — The test weld shall be 225 mm long as shown in Fig. 21. The weld shall be deposited in a single run using the forward method in the flat position.

The weld shall be stopped and restarted within the central 50 mm of the run. A sealing run on the reverse side is not permitted, so that the degree of root penetration can be subsequently examined.

19.5.6 *Assessment*

19.5.6.1 *Visual examination* — The weld shall be visually examined for dimension of a deposit, shape of profile, uniformity of surface, degree of undercut, smoothness of joints, freedom from surface defects, penetration, etc, as under **16.1**.

19.5.6.2 *Destructive tests* — The test specimen shall be cut out by machining as indicated in Fig. 21 and tested as under:

a) *Etch test* — One of the cut surfaces of the test specimen shall be prepared and etched and then visually examined as under **16.1** and **16.2**.

b) *Bend test* — The top and underside of the two bend test specimens shall be dressed flush. When bent through 180° over a former thrice the thickness of the sheet, each specimen shall show no crack or defect attributable to defective workmanship. Slight cracking at the ends of the weld metal occurring during bending may be disregarded. One specimen shall be tested with the face and the other with the root in tension.

c) *Nick break test* — The test specimen shall be notched as indicated in Fig. 21, broken open along the weld and the fractured surface visually examined as under **16.2**.

19.6 Test No. 6 Oxy-Acetylene Butt Welds in Brass Sheet 3·15 mm Thick

19.6.1 *Parent Metal* — The parent metal shall be as specified in the code.

19.6.2 *Position* — The test welds shall be deposited in the flat position (slope 0°, rotation 0°).

19.6.3 *Assembly for Welding* — The test piece shall conform to the requirements of Fig. 21. The plate edges may be prepared by shearing, machining or filing. The tack welds shall be on the side to be welded in the line of the weld. No other method of restraint shall be used. Distortion or misalignment caused by tacking may be corrected before the test weld is deposited. The test piece shall be supported in such a manner that contact with the bench or other material does not provide a backing for the joint.

19.6.4 *Filler Rod* — The filler rod used shall be 3·15 mm in diameter and of the type as specified in the code.

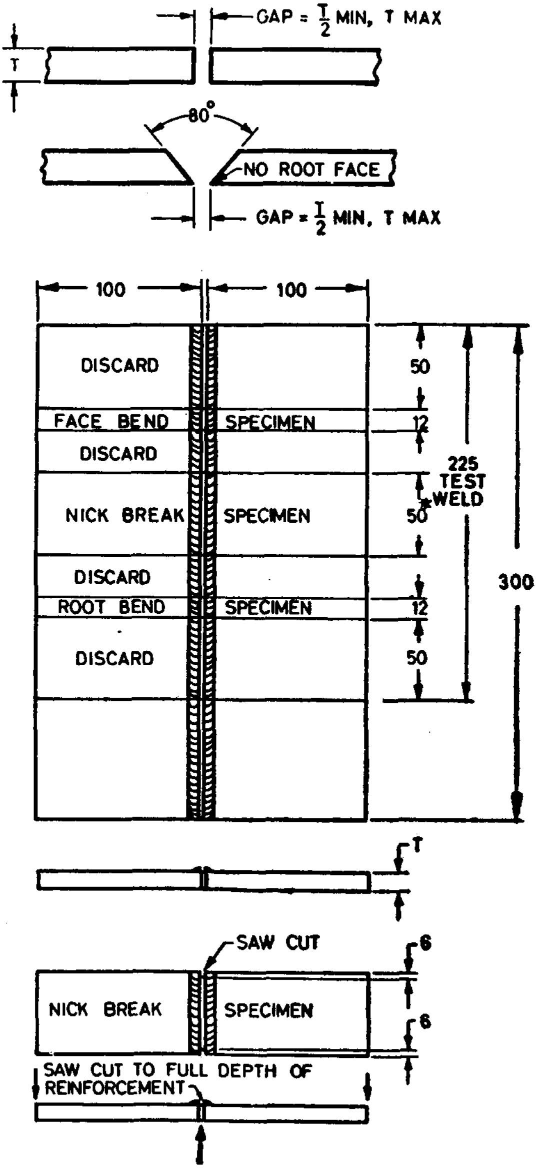
NOTE — Suitable flux should be used.

19.6.5 *Deposition of Test Weld* — The test weld shall be 225 mm long as shown in Fig. 21. The weld shall be deposited in a single run using the forward method in flat position.

The weld shall be stopped and started within the central 50 mm of the run. A sealing run on the reverse side is not permitted, so that the degree of root penetration can be subsequently examined.

19.6.6 *Assessment*

19.6.6.1 *Visual examination* — The weld shall be visually examined for dimension of deposit, shape of profile, uniformity of surface, degree of undercut, smoothness of joints, freedom from surface defects, penetration, etc, as under **16.1**.



*Weld to be stopped and restarted within central 50 mm of run.

All dimensions in millimetres.

FIG. 21 OXY-ACETYLENE BUTT WELDS IN PURE ALUMINIUM AND BRASS SHEETS 3·15 mm THICK

19.6.6.2 *Destructive tests* — The test specimen shall be cut out by machining as indicated in Fig. 21 and tested as under:

a) *Etch test* — One of the cut surfaces of the test specimen shall be prepared and etched and then visually examined as under **16.1** and **16.2**.

b) *Bend test* — The top and underside of the two bend test specimens shall be dressed flush. When bent through 180° over a former thrice the thickness of the sheet, each specimen shall show no crack or defect attributable to defective workmanship. Slight cracking at the ends of the weld metal occurring during bending may be disregarded. One specimen shall be tested with the face and the other with the root tension.

c) *Nick break test* — The test specimen shall be notched as indicated in Fig. 21, broken open along the weld and the fractured surface visually examined as under **16.2**.

19.7 Test No. 7 Oxy-Acetylene Fusion Butt Weld in Cast Iron Plate 12 mm Thick

19.7.1 *Parent Metal* — The parent metal shall be as specified in the code.

19.7.2 *Position* — The test piece shall be in flat position (slope 0°, rotation 0°) only.

19.7.3 *Assembly for Welding* — The test piece shall conform to the requirements of Fig. 22. The edge may be prepared by machining or grinding or cast plates with prepared edges may be used. Tack welds, if used, shall be on the side to be welded and in the line of the weld. No other form of restraint shall be used. The test piece shall be supported in such a manner that contact with the bench or other material does not provide a backing for the joint. Pre-heating the plates prior to welding with the blow pipe shall be permitted.

19.7.4 *Filler Rod* — The filler rod shall be 6 mm in diameter and of the type specified in the code.

NOTE — A suitable flux shall be used.

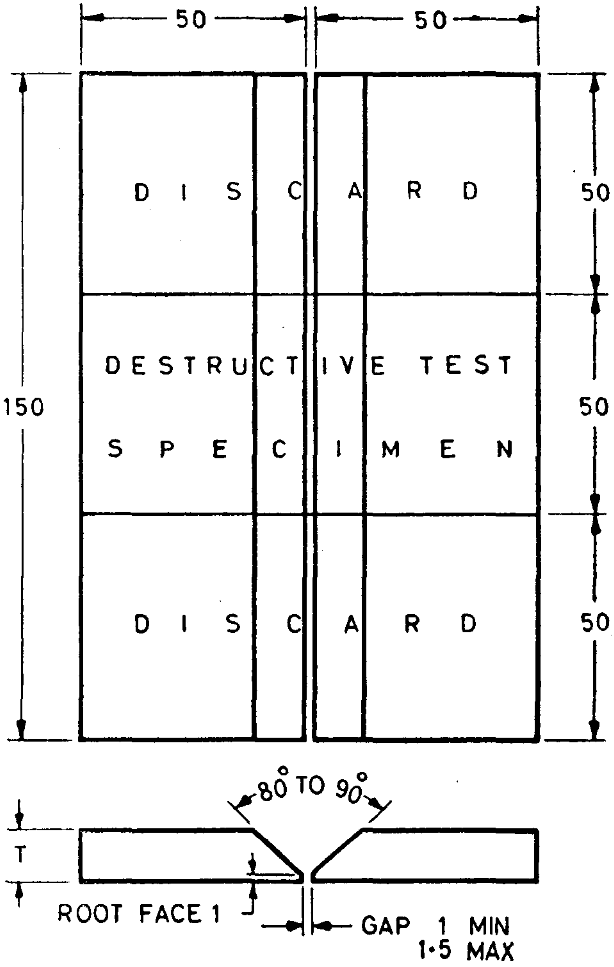
19.7.5 *Deposition of Test Weld* — The deposit shall be 150 mm in length as shown in Fig. 22, using forward method.

19.7.6 *Assessment*

19.7.6.1 *Visual examination* — The weld shall be visually examined for dimension of deposit, shape of profile, degree of undercut, freedom from surface defects, penetration, etc, as under **16.1**.

19.7.6.2 *Destructive test* — The test specimen shall be cut by machining as indicated in Fig. 22 and tested as under:

Nick break test — The test specimen shall be notched as indicated in Fig. 22, broken open along the weld and the fractured surface visually examined for hard spots and as under **16.2**.



All dimensions in millimetres.

FIG. 22 OXY-ACETYLENE FUSION BUTT WELD IN CAST IRON PLATE 12 mm THICK

19.8 Test No. 8 Oxy-Acetylene Braze-Butt Welds in Cast Iron Plate 12 mm Thick

19.8.1 *Parent Metal* — The parent metal shall be as specified in the code.

19.8.2 *Position* — The test weld shall be deposited in the appropriate position:

Flat	(slope 0°, rotation 0°)
Vertical	(slope 90°) upward method

19.8.3 *Assembly for Welding* — The test piece shall conform to the requirements of Fig. 23. The edges may be prepared by machining or cast plates with prepared edges may be used. Surface oxide may be removed by filing, machining, chiselling, shotblasting, etc. A ground finish is not recommended.

19.8.4 *Filler Rod* — The filler rod shall be 6 mm in diameter and of the type specified in the code.

NOTE — A suitable flux shall be used.

19.8.5 *Deposition of Test Weld* — The deposit shall be 150 mm in length as shown in Fig. 23, using forward method.

19.8.6 *Assessment*

19.8.6.1 *Visual examination* — The weld shall be visually examined for dimension of deposit, shape of profile, degree of undercut, freedom from surface defects, penetration, etc, as under **16.1**.

19.8.6.2 *Destructive test* — The test specimens shall be cut by machining as indicated in Fig. 23 and the cut face shall be prepared and polished. The joint shall show satisfactory penetration, adhesion and freedom from porosity in all sections examined.

20. RE-TEST FOR INITIAL QUALIFICATION TEST

20.1 In case a trainee fails to meet the requirements of one or more tests mentioned under **19.1** to **19.8**, a re-test may be allowed immediately or after some further training on the following conditions:

a) An immediate re-test shall consist of two test welds of each type in which the trainee failed. The re-test welds shall meet all the requirements specified for such welds.

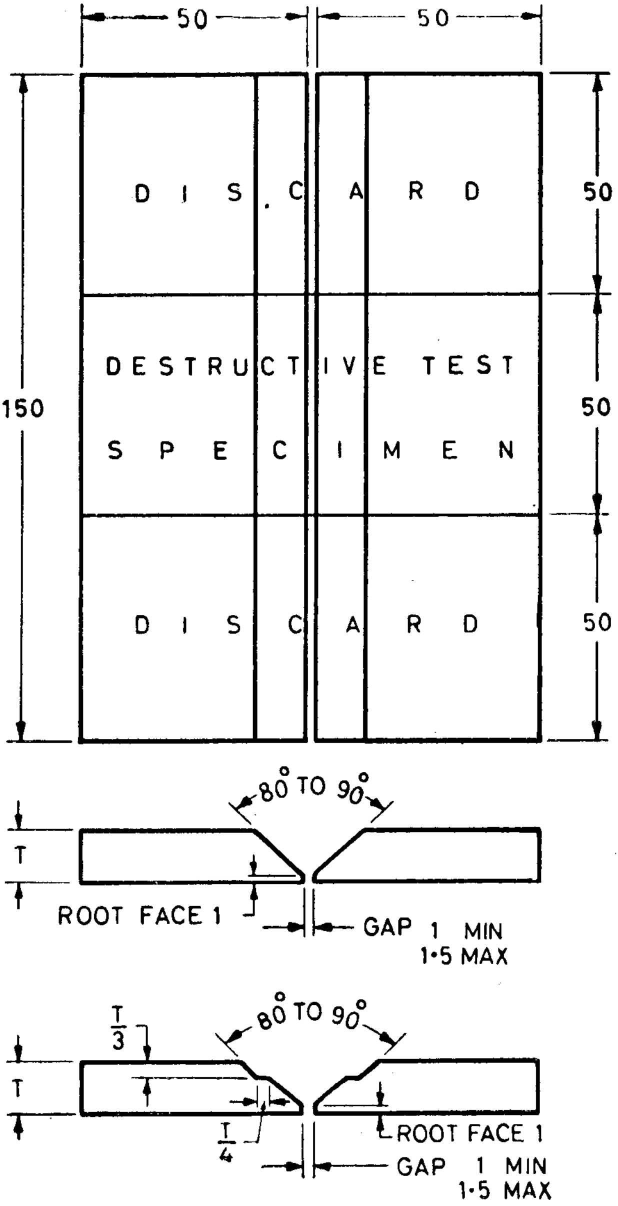
b) If the re-test is made after the trainee has had further training or practice, the complete initial qualification test shall be repeated.

20.2 Validity of Initial Qualification Test Certificates

20.2.1 The certification implied in passing of the initial qualification test is valid only when the holder is employed as a welder within six months of the passing of the test. The certification shall lapse automatically if, for any reason, he has not worked as a welder for a period of six months or more. Such lapsed certification shall be re-instated provided annual tests specified under **19** are passed.

21. ANNUAL TESTS

21.1 General — The annual tests to be taken by a welder, and the results of which are to be entered on his record book (*see* **7**), shall comprise of making test pieces and testing procedure as given under **19.1** to **19.8**.



All dimensions in millimetres.

FIG. 23 OXY-ACETYLENE BRAZE-BUTT WELDS IN CAST IRON PLATE 12 mm THICK

22. PERIODIC CONTROL TEST

22.1 The periodic control test consists of making butt welds and testing these as per initial qualification test and should be done at regular intervals of six months. Welders engaged continually on work that is subject to examination by some non-destructive testing method, such as radiographic, need not be subjected to the periodic control test. The preparation of test piece and testing procedure for the periodic control test shall be same as those prescribed for the initial qualification test.

23. RE-TESTS FOR ANNUAL TEST AND PERIODIC CONTROL TEST

23.1 Re-Tests for Annual Test — If the welder fails in the annual test, although periodic control tests have not shown any specific reason to question his ability, he shall be re-tested immediately. The re-test shall consist of two test welds of each type on which he fails. The test welds shall meet all the requirements specified for such welds. If the trainee fails in such a re-test, he shall be employed on unimportant work for some period and then resubmitted to the initial qualification test.

23.2 Re-Tests for Periodic Control Test — If the results of the periodic control tests indicate that there is some reason to question the welder's ability, then he shall be submitted to the tests prescribed for the annual test. If he fails in this test, he shall be put on unimportant work for a period and then resubmitted to the initial qualification test. The welder shall not be permitted to re-start on important work until he has passed the annual test or the initial qualification test, as the case may be.

24. POSITION FOR TEST WELDS

24.1 In the initial qualification test, the annual test and the periodic control test, the position for the test welds would depend on the welding positions for which the trainee or welder is to be certified or passed. The minimum requirements of test welds shall be as given in Table VIII under Appendix F.

24.2 The entries made in the Record Book (*see* **7**) shall have a reference to the welding positions for which the tests have been conducted and passed.

APPENDIX A

(*Clause* 7.2)

RECOMMENDED FORM FOR RECORD BOOK

(Page 1 of Book)

(*Name of Training Establishment*)

(City) . . . .

(State) . . . .

This Record Book certifies that . . . .
(*Full name of trainee*)

whose signature and identification are shown on the reverse, has completed a course of oxy-acetylene welding and cutting to the Indian Standard Code of Practice for Training and Testing of Oxy-Acetylene Welders (IS : 1393-1961) and has fulfilled all the requirements prescribed therein. The duration of the course and the details of the tests which the trainee has successfully passed are stated on the reverse.

Official Seal of Training Establishment	(*Signature of Training Establishment Officer*) (*Designation of Officer*) (*Date of Issue*)

(Page 2 of Book)

Title of Course . . . .

Duration of Course:

Total hours . . . .
Hours of actual welding practice . . . . .
Hours of observation of welding, preparing plates for welding, testing specimens, etc . . . .
Hours of instruction in theory . . . . . .

Photograph of Trainee

Visible Identification Marks

1) . . . .

2) . . . .

(*Signature of Trainee*)

Tests in which the Trainee has passed the Initial Qualification Test

DESCRIPTION OF WELDS	POSITION OF WELDING	DATE OF TEST	REMARKS	*TESTS NOT TAKEN
Section I				
Butt — Mild Steel 3·15 mm	Flat Vertical (upward)			*Punch here tests not taken
Fillet — Mild Steel 1·60 mm	Horizontal-vertical Vertical (upward)			
Corner — Mild Steel 1·60 mm	Flat Vertical (upward)			
Mild Steel Tube up to 1·60 mm wall thickness	Flat All-position			

*A punch mark in this column is an indication that the trainee did not take (or he failed to pass) the test in the relevant position.

(*Continued*)

(Page 2 of Book) — *Contd*

DESCRIPTION OF WELDS	POSITION OF WELDING	DATE OF TEST	REMARKS	*TESTS NOT TAKEN
Section II				
Cast-Iron — Fusion Welding	Flat			*Punch here tests not taken
Cast-Iron — Braze Welding	Flat Vertical (upward method)			
Brass-Butt — 3·15 mm	Flat			
Aluminium-Butt—3·15 mm	Flat			
Oxygen Cutting				
Flame Gouging				

*A punch mark in this column is an indication that the trainee did not take (or he failed to pass) the test in the relevant position.

(*Signature of Instructor*)

(Pages 3 to 12 of Book)

Record of Annual Tests

DESCRIPTION OF WELDS	POSITION OF WELDING	DATE OF TEST	REMARKS	*TESTS NOT TAKEN
Section I				*Punch here tests not taken
Butt — Mild Steel 3·15 mm	Flat Vertical (upward)			
Fillet — Mild Steel 1·60 mm	Horizontal-vertical Vertical (upward)			
Corner — Mild Steel 1·60 mm	Flat Vertical (upward)			
Mild Steel Tube up to 1·60 mm wall thickness	Flat All-position			
Section II				*Punch here tests not taken
Cast-Iron — Fusion Welding	Flat			
Cast-Iron Braze Welding	Flat Vertical (upward method)			
Brass-Butt — 3·15 mm	Flat			
Aluminium-Butt — 3·15 mm	Flat			
Oxygen Cutting				
Flame Gouging				

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*A punch mark in this column is an indication that the trainee did not take (or he failed to pass) the test in the relevant position.

(Particulars of Shop or Factory conducting Tests)

Official Seal of Office or Factory

(*Signature of Officer*)

(*Designation of Officer*)

. . . .

. . . .

(*Date of Issue*)

(Pages 13 to 16 of Book)

Record of Periodic Tests and Special Tests Taken

Description of Test . . . .
. . . .
. . . .

Remarks about passing of Test . . . .
. . . .

(Particulars of Shop or Factory conducting Test)	Official Seal of Office or Factory	(*Signature of Officer*)
		(*Designation of Officer*)
. . . .		(*Date of Issue*)

APPENDIX B

(*Clause* 8.2)

RECOMMENDED DESIGN OF POSITIONING EQUIPMENT

B-1. INTRODUCTION

B-1.1 The positioning equipment is designed to hold and position plates while the trainee is busy in performing welding exercises and tests. The purpose of such equipment is to provide a convenient method for holding any kind of joint (butt joint, lap joint, tee joint or corner joint) so that it may be welded in the flat, horizontal, vertical or overhead position.

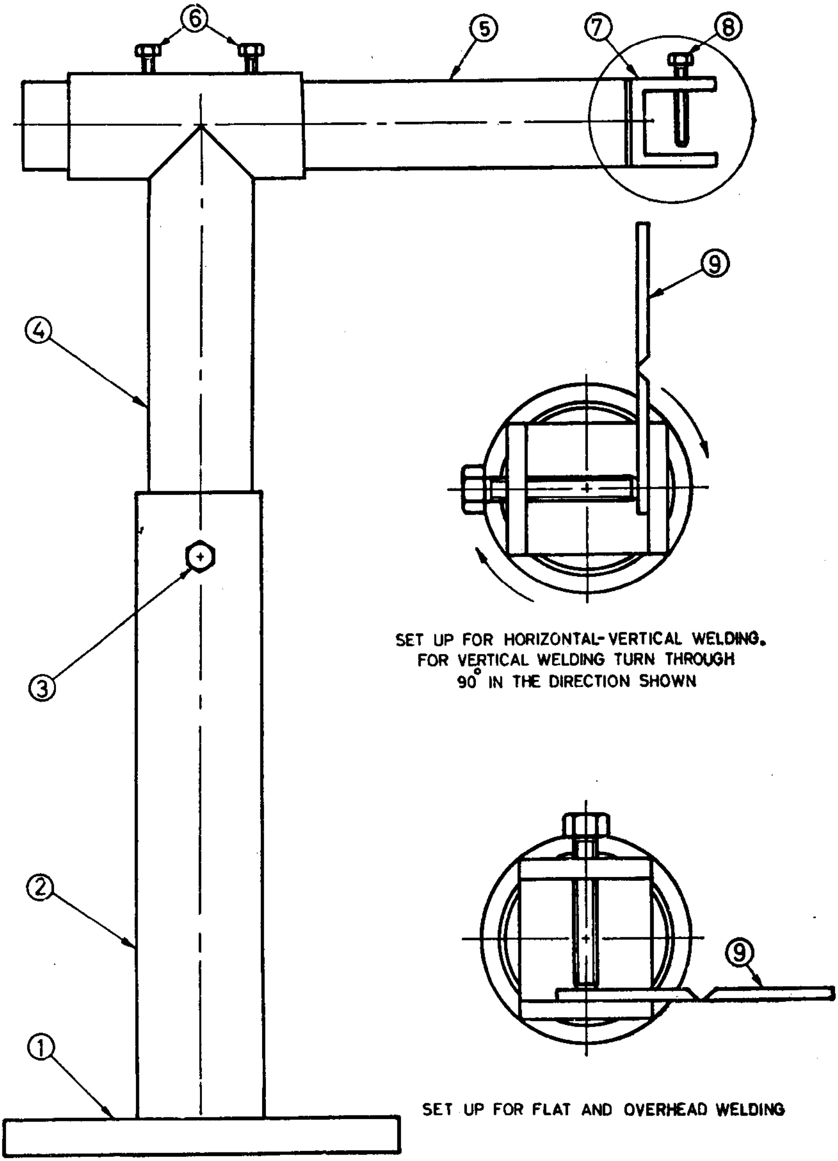
B-1.2 The plates shall be tack welded to form the specimen before fixing it in the positioning equipment.

B-1.3 This appendix describes the general features of the positioning device and illustrates its application.

B-1.4 The equipment can be readily constructed in the average machine shop and welding shop. One should be provided for each welding booth.

B-2. DESCRIPTION OF EQUIPMENT

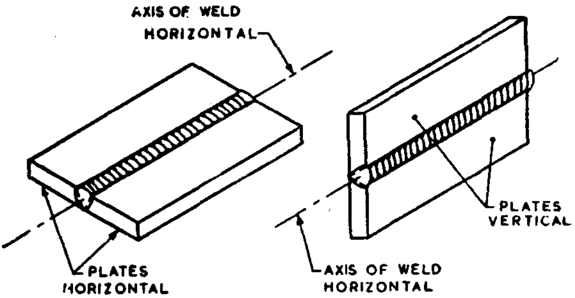
B-2.1 One type of complete positioning equipment, including all jigs and fixtures, is illustrated in Fig. 24 and the details are as shown.


6
5
7
8
9
4
3
SET UP FOR HORIZONTAL-VERTICAL WELDING.
FOR VERTICAL WELDING TURN THROUGH
90° IN THE DIRECTION SHOWN
2
9
1
SET UP FOR FLAT AND OVERHEAD WELDING

1. Working table
2. Column
3. Screw for fixing the sliding portion of column
4. Sliding portion of column
5. Horizontal arm
6. Screws for fixing the horizontal arm
7. Plate holder
8. Screw to hold the specimen
9. Specimen

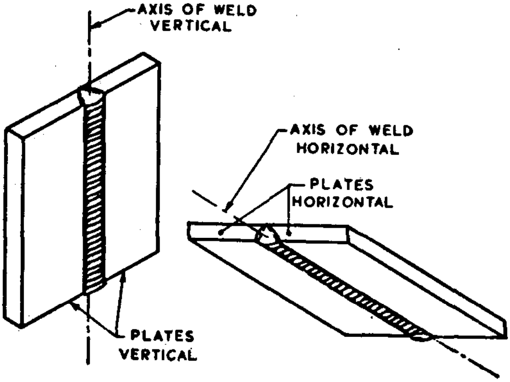
FIG. 24 ILLUSTRATION OF ALL POSITION JIG

B-2.2 Figures 25A to 25D illustrate the orientation of plates for butt welding in the flat, horizontal-vertical, vertical and overhead positions. The orientation of plates for fillet welding in the flat, horizontal, vertical, vertical and overhead positions, is illustrated in Fig. 26A to 26D.



25A Position of Plates for Flat Butt Weld

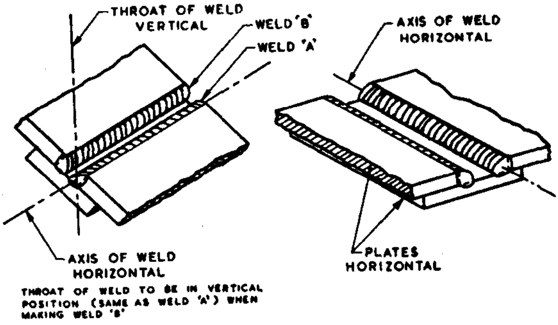
25B Position of Plates for Horizontal-Vertical Butt Weld



25C Position of Plates for Vertical Butt Weld

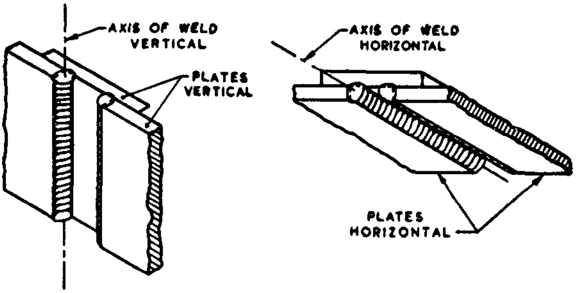
25D Position of Plates for Overhead Butt Weld

FIG. 25 POSITIONS OF PLATES FOR BUTT WELDS



26A Position of Plates for Flat Fillet Weld

26B Position of Plates for Horizontal-Vertical Fillet Weld



26C Position of Plates for Vertical Fillet Weld

26D Position of Plates for Overhead Fillet Weld

FIG. 26 POSITION OF PLATES FOR FILLET WELDS

APPENDIX C

(*Clause* 8.3)

ACCESSORIES AND EQUIPMENT RECOMMENDED FOR TRAINING ESTABLISHMENT FOR WELDERS

C-1. SHOP MACHINES AND ACCESSORIES

C-1.1 The training establishment shall be provided with the following shop and necessary equipment:

a) Heavy work bench with machinist's or blacksmith's vice weighing 30 kg or more;

b) Plate shear for preparing plates for welding and for cutting test specimens;
c) Two-ended pedestal grinder with 25 × 3 cm (or larger) course wheels and wheel dresser;
d) Heavy power hack-saw (preferably with 25 cm width capacity) or horizontal metal band saw;
e) Portable or flexible shaft grinder;
f) Equipment for machining test specimens;
g) Bend test device with hydraulic jack of 8 metric tonnes or larger capacity;
h) Break or rupture device with hydraulic jack of 8 metric tonnes or larger capacity;
j) Fire extinguishers, chemical (non-foam type);
k) Fire buckets, water;
m) Sand bags for fire protection;
n) Scrap box, 90 × 60 × 30 cm;
p) Chart-board for progress chart, instructional charts and notices;
q) Small platform scales for weighing out filler rods (optional);
r) First aid kit;
s) Provision for sterilizing welding goggles, if there is likelihood of these being used by more than one trainee;
t) Anvil, 45 kg or heavier;
u) Display board for sample specimens of welding exercises; and
v) Hot metal quenching tank (a minimum of one tank between two trainees).

C-2. SMALL TOOLS AND ACCESSORIES

C-2.1 While welding, the following equipment should be available to each trainee:

a) Sledge hammer for rupturing check test specimens,
b) Ball peen hammer,
c) C-clamps,
d) Cold chisels,
e) Centre punches,
f) Scribers,
g) Metal rules,
h) Try squares,

j) Sets of metal marking steel stamps (letters and figures 5 mm),
k) Small steel wedges,
m) Medium coarse files for rounding edges of test specimens, and
n) Soapstone marking crayon.

C-3. REQUIREMENTS FOR EACH TRAINEE WHILE WELDING

C-3.1 While welding, each trainee shall be supplied with the following equipment:

a) Oxy-acetylene welding blow pipe with tips or welding heads suitable for welding 1·6 mm to 12 mm thick mild steel,
b) Oxygen regulator,
c) Acetylene regulator (where acetylene from cylinder is used),
d) About 5-m length of suitable oxygen hose with connections and hose clips,
e) About 5-m length of suitable acetylene hose with connections and hose clips,
f) Spark lighter,
g) Pair of short pick up tongs or heavy gas pipe pliers,
h) Goggles with suitable coloured filter lens and clear cover glass,
j) Safety goggles for use while grinding specimens,
k) Wire scratch brush, and
m) Leather gloves or gauntlets (if necessary).

C-3.2 In addition to the above, the following equipment, one set each per 6 to 10 trainees, shall be provided:

a) Oxy-acetylene cutting blow pipe with oxygen and acetylene regulator, hoses, etc,
b) Oxy-acetylene gouging blow pipe with oxygen and acetylene regulator, hoses, etc.

C-4. EQUIPMENT FOR TRAINEE OBSERVERS AND INSTRUCTORS WHILE OBSERVING

C-4.1 While welding, each instructor and trainee shall be supplied with the following equipment:

a) Goggles with suitable coloured filter lens and clear cover glass, and
b) Weld gauges.

NOTE — Facilities for showing motion pictures, filmstrips and slides have been found to be of assistance.

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APPENDIX D

(*Clause* 9.2)

RECOMMENDED FORM OF TRAINEE PROGRESS CHART

SECTION I — GROUP B					
Making Butt Welds in 1·60 mm Mild Steel Sheet — Position Vertical	Making Butt Welds in 3·15 mm Mild Steel Sheet — Position Flat	Making Check Test Specimen No. 1	Making Check Test Specimen No. 2	Making Check Test Specimen No. 3	Status of Progress OK
B2	B3	B4	B5	B6	

SECTION I — GROUP C								
Making Butt Welds in 3·15 mm Mild Steel Sheet — Position Vertical	Making Corner Welds in 1·60 mm Mild Steel Sheet — Position Flat	Making Corner Welds in 1·60 mm Mild Steel Sheet — Position Vertical	Making Fillet Welds in 1·60 mm Mild Steel Sheet — Position Horizontal-Vertical	Making Check Test Specimen No. 4	Making Check Test Specimen No. 5	Making Check Test Specimen No. 6	Making Check Test Specimen No. 7	Status of Progress OK
C1	C2	C3	C4	C5	C6	C7	C8	

SECTION I — GROUP D					
Making Butt Welds in Tubes	Making Branch Joints in Tubes	Making Fillet Welds — Between Tube and Sheet	Check Test Specimen No. 8	Check Test Specimen No. 9	Status of Progress OK
D1	D2	D3	D4	D5	

SECTION II — GROUP E						
Making Butt Welds in 1·60 mm Aluminium Sheet — Position Flat	Making Butt Welds in 3·15 mm Aluminium Sheet — Position Flat	Making Butt Welds in 1·60 mm Brass Sheet — Position Flat	Making Butt Welds in 3·15 mm Brass Sheet — Position Flat	Check Test Specimen No. 10	Check Test Specimen No. 11	Status of Progress OK
E1	E2	E3	E4	E5	E6	

SECTION II — GROUP F						
Making Fusion Butt Welds in 10 mm Cast Iron Plate — Position Flat	Making Fusion Butt Welds in 12 mm Cast Iron Plate — Position Flat	Making Braze-Butt Welds in 10 mm Cast Iron Plate — Position Flat	Making Braze-Butt Welds in 12 mm Cast Iron Plate — Position Flat	Check Test Specimen No. 12	Check Test Specimen No. 13	Status of Progress OK
F1	F2	F3	F4	F5	F6	

SECTION II — GROUP G				
Making Braze-Butt Welds in 10 mm Cast Iron Plate — Position Vertical	Making Braze-Butt Welds in 12 mm Cast Iron Plate — Position Vertical	Depositing Hardfacing Rod	Check Test Specimen No. 14	Status of Progress OK
G1	G2	G3	G4	

SECTION II — GROUP H				
Manual Oxygen Cutting	Flame Gauging	Check Test Specimen No. 15	Check Test Specimen No. 16	Status of Progress OK
H1	H2	H3	H4	

SUMMARY				
Date Entered Course	Estimated Time at Actual Welding Practice	Estimated Time Observing Weld and Testing Specimen	Date Course Completed	Comments, Including the Class or Division in which the Trainee is Placed or Reasons for Discontinuing the Course

F.

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APPENDIX E

(*Clause* 10.1)

RECOMMENDED SYLLABUS FOR TRAINING COURSE

(Based on 40 working hours per week)

	Details of Course	*Position*	*Hours of Instruction*
1st Week	*Theory*	—	10
	Welding and cutting equipment safety in welding		
	Demonstrations, Films and Discussions	—	8
	Fitting up the equipment, setting gas pressures, flame setting, etc		
	Practical	—	22
	Fitting up the equipment, setting gas pressures, flame setting, running beads with and without filler rods	Flat	
	Butt welds in 1·60 mm mild steel plates	Flat	
2nd Week	*Theory*	—	6
	Welding techniques Welding metallurgy — mild steel (sheet metal) Welding terms and symbols		
	Demonstrations, Films and Discussions	—	9
	Practical	—	25
	Butt welds in 1·60 mm mild steel sheets	Flat	
	Butt welds in 1·60 mm mild steel sheets	Vertical	
	Butt welds in 3·15 mm mild steel sheets	Flat	

RECOMMENDED SYLLABUS FOR TRAINING COURSE — *Contd*

	Details of Course	*Position*	*Hours of Instruction*
3rd Week	*Theory*	—	4
	Characteristics of filler rods		
	Possibilities and limitation of welding		
	Demonstrations, Films and Discussions	—	11
	Practical	—	25
	Butt welds in 3·15 mm mild steel sheets	Vertical	
	Corner welds in 1·60 mm mild steel sheets	Flat	
	Corner welds in 1·60 mm mild steel sheets	Vertical	
4th Week	*Theory*	—	5
	Inspection and testing of welds		
	Costing		
	Demonstrations, Films and Discussions	—	7
	Practical	—	28
	Butt welds in mild steel tube 1·60 mm wall thickness	Flat	
	Welds of branch connections Plate to tube welds	Flat and Horizontal-vertical	
5th Week	*Theory*	—	9
	Weld metallurgy — cast iron, aluminium, brass and bronze		
	Demonstrations, Films and Discussions	—	5
	Practical	—	26
	Butt welds in 1·60 mm aluminium sheet	Flat	
	Butt welds in 3·15 mm aluminium sheet	Flat	
	Butt welds in 1·60 mm brass sheet	Flat	
	Butt welds in 3·15 mm brass sheet	Flat	

RECOMMENDED SYLLABUS FOR TRAINING COURSE — *Contd*

	Details of Course	*Position*	*Hours of Instruction*
6th Week	*Theory*	—	8
	Welding of castings		
	Demonstrations, Films and Discussions	—	2
	Practical	—	30
	Fusion butt welds in cast iron	Flat	
	Braze-butt welds in cast iron	Flat	
7th Week	*Theory*	—	3
	Hardfacing		
	Demonstrations, Films and Discussions	—	15
	Practical	—	22
	Braze-butt welds in cast iron	Vertical	
	Hardfacing		
8th Week	*Theory*	—	5
	Oxygen cutting		
	Demonstrations, Films and Discussions	—	13
	Practical	—	22
	Manual oxygen cutting		
	Flame gouging		

APPENDIX F

(*Clause* 13.1.4 *and Appendix E*)

DETAILED SUGGESTIONS COVERING EACH SECTION AND GROUP OF EXERCISES

F-1. GENERAL

F-1.1 In the suggested list of exercises (*see* **F-2.1** and Table VIII), no specific recommendations are made as to the number of times each exercise should be repeated. The trainee should be required to perform each exercise to the satisfaction of the instructor, before being allowed to advance to the next exercise.

F-1.2 It is recommended that the trainee should test as many of his welds as possible as soon as these have been cooled in still air. Further, the instructor should inspect the test weld and point out to the trainee any defects that may be in evidence and the reason for such defect or failure of the joint. The techniques of testing shall be as prescribed for the check tests.

F-1.3 It is recommended that the size of the specimens, as indicated in the various illustrations, be maintained.

F-1.4 It is recommended that the pieces be set up and tack welded before welding.

F-1.5 To suit specific welding training requirements, special outlines may be made from among the suggested exercises given in Table VIII.

F-2. EXERCISES

F-2.1 Exercises suggested in Sections I and II are given in Table VIII.

TABLE VIII EXERCISES

(*Clauses* F-1.5 *and* F-2.1)

EXERCISE No.	UNIT OPERATION	PARENT METAL	FILLER ROD		FLAME	INSTRUCTIONS
			*Type	Size		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Section I — Group A						
A1	Fitting of equipment	—	—	—	—	Practise fitting up the equipment, adjusting gas pressures, testing for leaks
A2	Lighting and adjusting flame	—	—	—	Neutral-oxidizing and carburizing	Practise the adjustment of flame to carburizing, neutral and oxidizing, noting the difference in the flame appearance and melt condition
A3	Depositing continuous bead weld with or without filler rod	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Practise depositing continuous beads from left to right (forward method), ensuring that the bead welds are uniformly straight, have even build up, and are free from under-cutting and oxidation or burning
Section I — Group B						
B1	Making butt welds in flat position	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Practise making butt welds by the forward technique; ensure making correct tacks, alignment. Try and obtain full fusion, feed rod uniformly in the weld pool to avoid undercutting and to ensure full build-up. Stop the weld in the centre and start again. Try to obtain a smooth joint

*Clause reference of IS: 1278-1958.

(*Continued*)

TABLE VIII EXERCISES — *Contd*

EXERCISE No. (1)	UNIT OPERATION (2)	PARENT METAL (3)	FILLER ROD		FLAME (6)	INSTRUCTIONS (7)
			*Type (4)	Size (5)		
Section I — Group B (Contd)						
B2	Making butt welds in vertical position	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Same as in B1
B3	Making butt welds in flat position	Mild steel sheet 3·15 mm	**9.1** or **9.2**	3·15 mm	Neutral	Same as in B1
B4	Making check test specimen No. 1	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Weld the joint (*see* Fig. 6) in a single run in flat position. Stop the weld and restart within central 50 mm of run. Test the specimen by rupturing and etching (*see* **16** for test results required)
B5	Making check test specimen No. 2	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Weld the joint (*see* Fig. 6) in a single run in vertical position — upward method. Stop the weld and restart within central 50 mm of run. Test the specimen by rupturing and etching (*see* **16** for test results required)
B6	Making check test specimen No. 3	Mild steel sheet 3·15 mm	**9.1** or **9.2**	3·15 mm	Neutral	Weld the joint (*see* Fig. 6) in a single run in flat position. Stop the weld and restart within central 50 mm of run. Test the specimen by rupturing and etching (*see* **16** for test results required)

*Clause reference of IS : 1278-1958.

(*Continued*)

TABLE VIII EXERCISES — *Contd*

EXERCISE No.	UNIT OPERATION	PARENT METAL	FILLER ROD		FLAME	INSTRUCTIONS
			*Type	Size		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Section I — Group C						
C1	Making butt welds in vertical position	Mild steel sheet 3·15 mm	**9.1** or **9.2**	3·15 mm and 1·60 mm	Neutral	Same as in B1
C2	Making corner welds in flat position	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Same as in B1
C3	Making corner welds in vertical position	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Same as in B1
C4	Making fillet welds in horizontal-vertical position	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Same as in B1
C5	Making check test specimen No. 4	Mild steel sheet 3·15 mm	**9.1** or **9.2**	2·50 mm or 1·60 mm	Neutral	Weld the joint (*see* Fig. 6) in a single run in vertical position — upward method. Stop the weld and restart within central 50 mm of run. Test the specimen by rupturing and etching (*see* **16** for test results required)
C6	Making check test specimen No. 5	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Weld the joint (*see* Fig. 7) in a single run in flat position. Stop the weld and restart within central 50 mm of run. Test the specimen by rupturing and etching (*see* **16** for test results required)

*Clause reference of IS: 1278-1958.

(*Continued*)

TABLE VIII EXERCISES — *Contd*

EXERCISE No. (1)	UNIT OPERATION (2)	PARENT METAL (3)	FILLER ROD *Type (4)	FILLER ROD Size (5)	FLAME (6)	INSTRUCTIONS (7)
Section I — Group C (Contd)						
C7	Making check test specimen No. 6	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Weld the joint (*see* Fig. 7) in a single run in a vertical position — upward method. Stop the weld and restart within central 50 mm of run. Test the specimen by rupturing and etching (*see* **16** for test results required)
C8	Making check test specimen No. 7	Mild steel sheet 1·60 mm	**9.1** or **9.2**	1·60 mm	Neutral	Weld the joint (*see* Fig. 8) in a single run in horizontal-vertical position. Stop the weld and restart within central 50 mm of run. Test the specimen by rupturing and etching (*see* **16** for test results required)
Section I — Group D						
D1	Making butt welds in mild steel tubes in flat position	Mild steel tube 25 mm OD — 1·60 mm wall thickness	**9.1** or **9.2**	1·60 mm	Neutral	Same as in B1
D2	Making branch joint in mild steel tubes — angles — 45°, 90°, 135°	Mild steel tube 25 mm OD— 1·60 mm wall thickness	**9.1** or **9.2**	1·60 mm	Neutral	Same as in B1

*Clause reference of IS: 1278-1958.

(*Continued*)

TABLE VIII EXERCISES — *Contd*

EXERCISE No.	UNIT OPERATION	PARENT METAL	FILLER ROD		FLAME	INSTRUCTIONS
			*Type	Size		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Section I — Group D (Contd)						
D3	Making fillet welds — between tube and plate	Mild steel tube 25 mm OD — 1·60 mm wall thickness	**9.1** or **9.2**	1·60 mm	Neutral	Same as in B1
D4	Making check test specimen No. 8	Mild steel tube 25 mm OD — 1·60 mm wall thickness	**9.1** or **9.2**	1·60 mm	Neutral	Weld the joint (*see* Fig. 12) at an angle of 90° in one pass with 4 to 5 mm fillet weld in horizontal-vertical position. Cut the tee into four pieces by sawing. Test the sections by polishing and etching (*see* **16** for test results required)
D5	Making check test specimen No. 9	Mild steel tube 25 mm OD — 1·60 mm wall thickness	**9.1** or **9.2**	1·60 mm	Neutral	Weld the joint (*see* Fig. 13) in one pass with 4 to 5 mm fillet weld in flat and horizontal-vertical positions. Cut into four pieces. Test the sections by polishing and etching (*see* **16** for test results required)
Section II — Group E						
E1	Making butt welds in aluminium in flat position	Aluminium sheet 1·60 mm	**13.3**	3·15 mm	Neutral	Practise making butt welds in aluminium, appreciate the necessity of using flux; try and obtain full fusion and penetration without flux entrapment

*Clause reference of IS : 1278-1958.

(*Continued*)

TABLE VIII EXERCISES — *Contd*

EXERCISE No. (1)	UNIT OPERATION (2)	PARENT METAL (3)	FILLER ROD *Type (4)	FILLER ROD Size (5)	FLAME (6)	INSTRUCTIONS (7)
Section II — Group E (Contd)						
E2	Making butt welds in aluminium in flat position	Aluminium sheet 3·15 mm	**13.3**	3·15 mm	Neutral	Same as in E1
E3	Making butt welds in brass in flat position	Brass sheet 1·60 mm	**11.2**	3·15 mm	Oxidizing	Practise making butt welds in brass, appreciate the necessity of using oxidizing flame and flux, try and obtain full fusion and penetration
E4	Making butt welds in brass in flat position	Brass sheet 3·15 mm	**11.2**	3·15 mm	Oxidizing	Same as in E3
E5	Making check test specimen No. 10	Aluminium sheet 3·15 mm	**13.3**	3·15 mm	Neutral	Weld the joint (*see* Fig. 14) in a single run in flat position. Stop the weld and restart within central 50 mm of run. Test the specimen by rupturing and etching (*see* **16** for test results required)
E6	Making check test specimen No. 11	Brass sheet 3·15 mm	**11.2**	3·15 mm	Oxidizing	do
Section II — Group F						
F1	Making fusion butt welds in cast iron in flat position	Cast iron plate 10 mm	**10.1**	6 mm	Neutral	Practise making butt welds in cast iron using flux. Try making full fusion with sufficient penetration and obtain weld deposit free from porosity

*Clause reference of IS: 1278-1958.

(*Continued*)

TABLE VIII EXERCISES — *Contd*

EXERCISE No. (1)	UNIT OPERATION (2)	PARENT METAL (3)	FILLER ROD *Type (4)	FILLER ROD Size (5)	FLAME (6)	INSTRUCTIONS (7)
Section II — Group F (Contd)						
F2	Making fusion butt welds in cast iron in flat position	Cast iron plate 12 mm	**10.1**	6 mm	Neutral	Same as in F1
F3	Making braze-butt welds in cast iron in flat position	Cast iron plate 10 mm	**10.1**	6 mm	Slightly oxidizing	Practise making braze-butt weld in cast iron, obtaining good bond and tinning, full penetration and build up, weld deposit free from porosity
F4	Making braze-butt welds in cast iron in flat position	Cast iron plate 12 mm	**11.3**	6 mm	Slightly oxidizing	Same as in F3
F5	Making check test specimen No. 12	Cast iron plate 12 mm	**10.1**	6 mm	Neutral	Weld the joint [*see* Fig. 15(A) and 16] in flat position by fusion welding technique. Cut the weld by sawing. Test the specimen by rupturing and etching (*see* **16** for test results required)
F6	Making check test specimen No. 13	Cast iron plate 10 mm	**10.1**	5 mm	Slightly oxidizing	Weld the joint [*see* Fig. 15(A) or 15(B) and 16] in flat position by braze welding. Cut the weld by sawing. Test the specimen by rupturing and etching (*see* **16** for test results required)

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*Clause reference of IS : 1278-1958.

(*Continued*)

TABLE VIII EXERCISES — *Contd*

EXERCISE No. (1)	UNIT OPERATION (2)	PARENT METAL (3)	FILLER ROD		FLAME (6)	INSTRUCTIONS (7)
			*Type (4)	Size (5)		
Section II — Group G						
G1	Making braze-butt welds in cast iron in vertical position	Cast iron plate 10 mm	**11.3**	6 mm	Slightly oxidizing	Same as in F3
G2	Making braze-butt welds in cast iron in vertical position	Cast iron plate 12 mm	**11.3**	6 mm	Slightly oxidizing	Same as in F3
G3	Depositing hard-facing rod	Mild steel 10 mm	Choice left to the training establishment			According to the directions of the maker of the rod
G4	Making check test specimen No. 14	Cast iron plate 10 mm	**10.1**	5 mm	Slightly oxidizing	Weld the joint [*see* Fig. 15(A) or 15(B) and 16] in vertical position — upward method, by braze-welding technique. Cut the weld by sawing. Test the specimen by rupturing and etching (*see* **16** for test results required)
Section II — Group H						
H1	Manual oxygen cutting	Mild steel 12 mm	—	—	—	Practice making straight cuts, piercing holes, bevel cuts, etc; try and obtain reasonably clean smooth edge without excessive top melting and cutting at uniform speed

*Clause reference of IS: 1278-1958.

(*Continued*)

TABLE VIII EXERCISES — *Contd*

EXERCISE No. (1)	UNIT OPERATION (2)	PARENT METAL (3)	FILLER ROD *Type (4)	FILLER ROD Size (5)	FLAME (6)	INSTRUCTIONS (7)
Section II — Group H (Contd)						
H2	Flame gouging	Mild steel plate 12 mm	—	—	—	Practise making grooves on plates, removing welds from ' T ' joints without damaging the plates, cutting panhead rivets, etc
H3	Making check test specimen No. 15	Mild steel plate 12 mm	—	—	—	Cut a 75 mm square hole in the centre of a 150 × 150 mm size plate following the profile as nearly as possible. Test the specimen for a reasonably clean cut (*see also* **15.4.3**)
H4	Making check test specimen No. 16	—	—	—	—	Remove a fillet weld from a tee joint. Examine that no damage has been done to the plates while removing the weld

*Clause reference of IS : 1278-1958.

APPENDIX G

(*Clause* 17.2.1)

RECOMMENDED SAFETY RULES

G-1. POSITIVE RULES

G-1.1 Wear leather gloves (if necessary), adequate clothing and heavy shoes, tightly laced.

G-1.2 Wear welding goggles when welding or when witnessing demonstration.

G-1.3 Remove combustible materials from the vicinity of welding or gas cutting operations.

G-1.4 Get prompt first aid if burnt or if your eyes have been injured by flying sparks.

G-1.5 Wear safety goggles when chipping or grinding.

G-1.6 Keep welding table and floor clean and clear of short length of rods, scraps of metal and carelessly disposed tools.

G-1.7 Know how to use the fire extinguishers and memorize their location.

G-1.8 See that hose connections are tight and that the tip of the torch is clean.

G-1.9 Make proper provision for venting exhaust gases when operating in confined spaces.

G-2. NEGATIVE RULES

G-2.1 Don't look at a welding or cutting operation with the naked eye.

G-2.2 Don't use cracked or defective goggles.

G-2.3 Don't hang a torch with its hose on regulators or cylinder valves.

G-2.4 Don't pick up hot objects.

G-2.5 Don't use defective equipment.

G-2.6 Don't weld on closed containers or on containers that have held combustible materials. (Secure permission from the instructor before welding on any container.)

G-2.7 Don't weld in the vicinity of inflammable or combustible materials.

G-2.8 Don't weld in confined spaces without adequate ventilation.

G-2.9 Don't attempt to repair equipment.

G-2.10 Don't play the flame on cylinders, hoses or other equipment.

NOTE — For detailed instructions for safety and health requirements in electric and gas welding and cutting operations, reference should be made to IS: 818-1957 Code of Practice for Safety and Health Requirements in Electric and Gas Welding and Cutting Operations.

APPENDIX H

[*Clauses* 19.1.6.2(a) *and* 19.2.6.2(a)]

*SUGGESTED METHODS FOR PREPARING ETCHED SPECIMENS

H-1. MILD STEEL

H-1.1 Preparation of Surface for Etching — The surface should be filed with a coarse file until all deep marks are removed. It should then be filed at right angles to the original coarse file marks with a smooth file. The smooth filed surface should be polished down with successively finer grades of emery paper, for example, ' M ', ' F ', ' O ', ' OO ', the direction of polishbeing being at right angles to the marks made by the previous paper in each case. Polishing should be continued until the scratches of the previous paper have been removed before proceeding to the next finer grade. This procedure is indicated in order to show the means by which a first-class finish may be obtained.

H-1.2 Etching for Macro-Examination — In general for steel, an ' O ' emery finish will be smooth enough for a satisfactory etch to be obtained for macro-examination. A suitable etching solution is prepared by mixing the following:

a) *Concentrated Nitric Acid* — 10 to 15 ml (conforming to IS: 264-1950 Specification for Nitric Acid), and

---

*The methods of preparing etched specimens are suggested for convenience and are in no way intended to be a rigid requirement of this code.

b) *Denatured Spirit* — 90 ml (conforming to IS : 324-1952 Specification for Denatured Spirit).

H-2. ALUMINIUM AND BRASS

H-2.1 Preparation of Surface for Etching — The surface should be filed with a medium file until all deep marks are removed. It should then be filed at right angles to the original medium file marks with smooth file until the surface is smooth and free from marks. The procedure is indicated so that a good finish may be obtained.

H-2.2 Etching for Macro-Examination — In general for aluminium and brass, the above finish will be smooth enough for a satisfactory etch to be obtained for macro-examination. Suitable etching solutions are prepared by mixing the following:

a) *For Aluminium*
   1) *Caustic soda solution* — 10 percent (*w*/*v*).
   2) *Dilute hydrochloric acid* — 1 : 9 (by volume).
   3) *Dilute nitric acid* — 1 : 4 (by volume).

b) *For Brass*
   1) *Dilute nitric acid* — 1 : 3 (by volume).
   2) *Ammonium persulphate solution* — 10 percent solution containing about 20 percent of ammonia.

H-3. PROCEDURE FOR ETCHING

H-3.1 The etching is carried out either by swabbing the surface with cotton wool or by immersing the specimen in the etching solution until a good definition of the structure is obtained. The specimen should then be washed in water, preferably hot, followed by rinsing with acetone or alcohol (industrial spirit) and dried in a current of air. If specimens are to be preserved, a coating of thin oil or colourless lacquer is of advantage.

APPENDIX J

(*Clause* 0.9)

EQUIVALENT fps VALUES OF METRIC VALUES USED IN THE STANDARD

METRIC UNITS	NEAREST fps EQUIVALENTS
mm	*in.*
1	$\frac{1}{32}$
1·5 1·60	$\frac{1}{16}$
2	$\frac{5}{64}$
2·50	$\frac{3}{32}$
3·15	$\frac{1}{8}$
4	$\frac{3}{32}$
5	$\frac{3}{16}$
6	$\frac{1}{4}$
10	$\frac{3}{8}$
12	$\frac{1}{2}$
25	1
40	$1\frac{1}{2}$
50	2
60	$2\frac{3}{8}$
75	3
150	6
225	9
300	12
cm	*in.*
25 × 3	10 × $1\frac{1}{4}$
90 × 60 × 30	36 × 24 × 12
25	10
kg	*lb*
30	70
45	100
metric tonnes	*tons*
8	8

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	Metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Suplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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